ARAB REPUBLIC OF EGYPT
MINISTRY OF WATER RESOURCES AND IRRIGATION
RESERVOIR AND GRAND BARRAGES SECTOR

THE ARAB REPUBLIC OF EGYPT THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS

DETAILED DESIGN STUDY

FINAL REPORT

May, 2017

JAPAN INTERNATIONAL COOPERATION AGENCY

SANYU CONSULTANTS INC.

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Preface

The Detailed Design Study on the Project for Construction of the New Dirout Group of Regulators has started on 1st July 2015. The study was executed in two (2) phases, consists of natural condition survey and basic design study as the first half, and the detailed design study as the last half. The Study was executed in the total study periods of one (1) year and 11 months, until the 7th of July 2017 when the contract period for this study terminates.

In the course of execution of the studies, the Basic Design Report was submitted at the end of July 2016, the Interim Report was submitted at the end of November 2017 as the intermediate phase of the detailed design study. The Final Report consists of the issues consistently on design, drawings, bill of quantities (BQ), construction plan, project cost estimation and draft bidding documents.

For the preparation of the Final Report, we made due consideration on the convenience and acceleration of understanding on the contents of this report by the users who will be engaged for the first time in each expected stage of the Construction Project of the New Dirout Group of Regulators, for their confirmation and understanding of the design concept on this report.

It is our great honor to be engaged in the Japanese Yen Loan Project with condition of the STEP (Special Terms for Economic Partnership) which is the first case to be applied in the irrigation sector in Japan’s Official Development Assistance. We sincerely desire that this Final Report will contribute to the high quality of works on the Construction of the New Dirout Group of Regulators, of which the implementation is expected to start in the near future.

Last of all, JICA Study Team wishes to express the sincerest appreciation to the officials concerned of the Japan International Cooperation Agency and Ministry of the Water Resources and Irrigation, the Arab Republic of Egypt who gave precious comments and guidance to the team.

May, 2017

EXECUTIVE SUMMARY

1. Outline of Design

The Dirout Group of Regulators (hereinafter referred to as “DGRs”), which is the subject of this study, is the core irrigation infrastructure to supply irrigation water to all the beneficiary area located in the middle Nile basin region. The DGRs delivers 9.6 BCM/year of irrigation water or 17% of the gross water resource of the Nile of 55.5 BCM/year taken from the Assiut Barrage into the beneficiary area of 0.6 million ha through the Ibrahimia main canal. The DGRs branches the Ibrahimia main canal into seven (7) main canals, and irrigation water is provided to the beneficiary area through these canals.

The Bahr Yusef canal is the largest canal in capacity among the seven (7) canals. Its length extends as long as 312 km and there are four (4) regulators, namely the Lahoun Regulator, the Mazoura Regulator, the Sakoula Regulator and the Dahab Regulator, all of which were rehabilitated by Japan’s Grand Aid from 1995 to 2010.

The DGRs, which was constructed in 1872, is the oldest active regulator in the country, and the weirs cannot function well due to their age. The rehabilitation of the DGRs should, therefore, be urgently implemented. It is expected that the impacts of the rehabilitation of the DGRs should be significant considering the vast beneficiary area and very long canal networks by synergy with the rehabilitation of four (4) regulators in the Bahr Yusef canal.

In view of such a situation, Japan International Cooperation Agency (hereinafter referred to as “JICA”) conducted the feasibility study, namely “The Preparatory Survey for the Rehabilitation and Improvement of the Dirout Group of Regulators in the Arab Republic of Egypt” (hereinafter referred to as “F/S”), in 2010 in order to formulate the rehabilitation plan of the DGRs and integrated water management plan for the operational management of the DGRs and other regulators along the Bahr Yusef canal.

The Egyptian Government requested of the Japanese Government the Official Development Assistance (hereinafter referred to as “ODA”) loan, which applied Special Terms for Economic Partnership (hereinafter referred to as “STEP”), in March 2013. On March, 2015, JICA signed an ODA loan agreement for the Project for Construction of the New Dirout Group of Regulators (hereinafter referred to as “the Project”) with the Egyptian Government after a series of discussions. This study will be conducted for twenty-two (22) months from July 2015 in compliance with the Record of Discussion (hereinafter referred to as “R/D”) signed by JICA and the Ministry of Water Resources and Irrigation (hereinafter referred to as “MWRI”) on March, 2015, in order to prepare the detailed designs and bidding of documents.

2. Design of the Regulators

2-1 Design conditions

Adherence to the Egyptian code is given first priority in the design criteria applied at the basic design and the detailed design stages for NDGRs construction project, which is supplemented by " Part No.2 Design of Hydraulic Structure, Spillways, Regulators and Barrage" used as the design criteria for the hydraulic facility in Egypt. In the absence of a policy in the Egyptian code regarding an issue, Japanese design criteria in the field of the regulators and *Design Criteria for Irrigation and Drainage, Headworks* will be referred to.

Figure 2-1 and Table 2-1 show the outline of the NDGRs

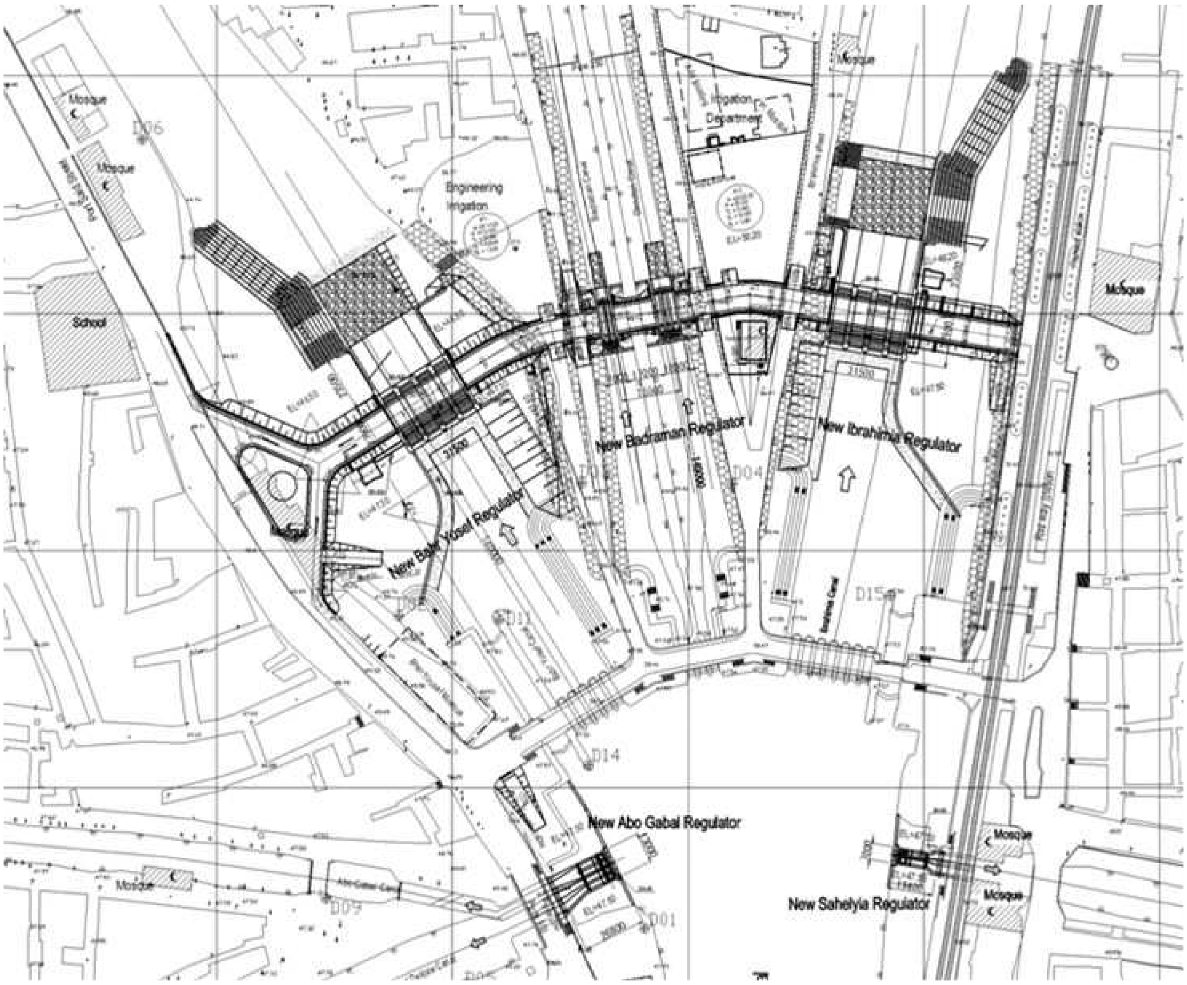


Figure 2-1 General layout of NDGRs

Table 2-1 Outline of NDGRs

Name of Regulator		Bahr Yusef	Ibrahimia	Badraman		AboGabal		Sahelyia	Remarks
Name of Canal				Badraman	Diroutiah	AboGabal	Irad Delgaw		
Design maximum discharge		227 m^3/s	186 m^3/s	9 m^3/s	12 m^3/s	7 m^3/s	9 m^3/s	5 m^3/s	Total 455m^3/s
Design minimum discharge		33.1 m^3/s	23.6 m^3/s	1.2 m^3/s	1.7 m^3/s	0.9 m^3/s	1.3 m^3/s	0.6 m^3/s	Total 60.7m^3/s
Design U/S high water level		EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	
Design U/S low water level		EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	
Design D/S high water level		EL45.82m	EL45.13m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	
Width of vent		6.00m	6.00m	2.00m	2.00m	2.00m		2.00m	
Number of vent		4	4	2	3	4		2	
Gate sill elevation		EL40.00m	EL40.00m	EL43.90m	EL44.20m	EL43.60m		EL43.00m	
Gate crest elevation		EL46.55m	EL46.55m	EL46.55m	EL46.55m	EL46.55m		EL46.55m	
Total gate height		6.55m	6.55m	2.65m	2.35m	2.95m		3.55m	
Foundation	Main body	Cast-in-place RC pile	Cast-in-place RC pile	Raft foundation	Raft foundation	Raft foundation		Raft foundation	
	Apron	Raft foundation	Raft foundation	Raft foundation	Raft foundation	Raft foundation		Raft foundation	
	L-shape wall	Cast-in-place RC pile	Cast-in-place RC pile	-	-	-		-	
Downstream apron	Type	L-type retaining wall	L-type retaining wall	RC flume	RC flume	RC flume		RC flume	
	Length	44.25m	44.25m	23.35m	22.77m	23.87m		16.42m	Note(1)
Seepage control works		Steel sheet pile	Steel sheet pile	Steel sheet pile	Steel sheet pile	Steel sheet pile		Steel sheet pile	
Bed protection works		Riprap L=30.0m (D_{50}=0.40m,W_{50}=60kg,t=1.00m)	Riprap L=30.0m (D_{50}=0.40m,W_{50}=60kg,t=1.00m)	Riprap L=15.0m (D_{50}=0.20m,W_{50}=10kg,t=0.50m)	Riprap L=15.0m	–		–	t : Thickness including gravel (0.10m)
Bank protection works	D/S	Cantilevered type/Brace type steel sheet pile wall	Cantilevered type/Brace type steel sheet pile wall	Cantilevered sheet pile wall	Cantilevered sheet pile wall	–		–	
		Gabion wall	Gabion wall						
	U/S	Brace type steel sheet pile wall	Cantilevered type/Brace type steel sheet pile	Cantilevered sheet pile wall	Cantilevered sheet pile wall	Brace type steel sheet pile wall		Brace type steel sheet pile wall	
		Wet stone pitching	Wet stone pitching						
Bridge		RC, Total width=12.5m	RC, Total width=12.5m	RC,Total width=12.5m	RC,Total width=12.5m	RC,Total width=6.0m		RC,Total width=6.0m	
Gate facility	Type	Double leaf Fixed wheel gate	Double leaf Fixed wheel gate	Single leaf Slide gate	Single leaf Slide gate	Single leaf Slide gate		Single leaf Slide gate	
	Hoist	Hydraulic cylinder	Hydraulic cylinder	Electric motor	Electric motor	Electric motor		Electric motor	
	Operation speed	0.3 m/min	0.3 m/min	0.3 m/min	0.3 m/min	0.3 m/min		0.3 m/min	
	Material	Rolled steel & Stainless steel(Guide frame, bolt & nut, wheels)							
	Stoplogs	1 set	1 set	2 sets					Note(2)
		Height of one piece=1.35m&1.20m		Height of one piece=0.95m&0.85m					
Management facility		Remote control building: RC structure, 2 floors (Stoplogs storage house is established together)							Location and the area is under study
		Local control room: RC structure, 2 rooms (Bahr Yusef & Ibrahimia Regulator)							
Water level gauge		2 sets (U/S:1,D/S:1)	2 sets (U/S:1,D/S:1)	2 sets (U/S:1,D/S:1)	2 sets (U/S:1,D/S:1)	3 sets (U/S:1,D/S:2)		2 sets (U/S:1,D/S:1)	Pressure type

Note: (1) Length of downstream apron for small regulators shows the distance from a gate sill to the existing structure.
(2) One set means a pair of stoplogs for upstream and downstream.
U/S:Upstream, D/S:Downstream

2-2 Operation and Maintenance of regulators

The outline of the operation and maintenance of the NDGRs are shown on the Table 2-2.

Table 2-2 Outline of operation and maintenance of NDGRs

List of operation and maintenance	Outline of operation and maintenance
Management and control of water distribution	Management and control of the water distribution which is necessary to make the yearly plan should be cooperated with the other operators at U.S. and D.S. of NDGRs. The gate operators should control the water discharge from the gates depending on the water level at U.S and D.S.
Maintenance of structures and buildings in NDGRs	In order to secure the structure and function for the longtime, the status check and the rehabilitation are important to conduct properly.
Maintenance of equipment	The equipment, i.g, observation, machine and electric facility, needs proper maintenance. The method of maintenance on the gate facilities are shown as followings; Inspection → Maintenance → Operation. Those works flow should be repeated as the cycle works. The necessary rehabilitation and overhaul to the equipment and the facility should be done if the deteriorations are discovered.
Record of inspection and check	The as build drawings and the design document should be kept in the custody so as to use as the necessity. The records of the inspection and check should be organized into the database and kept for a long term.
Management of target canal bed elevation	The sedimentation at the downstream of the gates could be made adverse effect to the gate operation such as closing completely. The canal bed level at the vicinity of the regulators should be less than the sill level of the gates.

2-3 Proposal for preservation works of the existing DGRs

(1) Prerequisites for examination of preservation measures

As the prerequisites for the proposal on the necessary and reasonable works of the preservation of the existing DGRs, the following purposes and the deterioration curve shown on Figure 2-2 should be utilized for the examination.

① To preserve the existing DGRs as a historical monument.
② To the practical functions of regulators by the removal of the gate or keeping the gates open completely.
③ To remain the bridge function with some traffic restrictions for large and heavy vehicles.

(2) Proposal for necessary survey and feasible measures based on present data

In order to explore the appropriate preservation measures, the visual inspection, the boring survey, the laboratory test and structural analysis should be done in addition to the past study and survey. The feasible measures based on the present available data are shown as followings;

- ✓ In order to reduce the burden load on the existing DGRs except for Abo Gabal and Sahelyia regulators, the passable traffic shall be restricted.
- ✓ All the gates shall be opened completely to alleviate the up-lift pressure to the basement of the regulators.
  (The necessary dredging works should be done before the gates opens.)
- ✓ The significant damage found in the past (2010) survey such as eroded and fallen out bricks inside of the vents and the apron erosion at Bahr Yusef and Ibrahimia regulators should be rehabilitated.

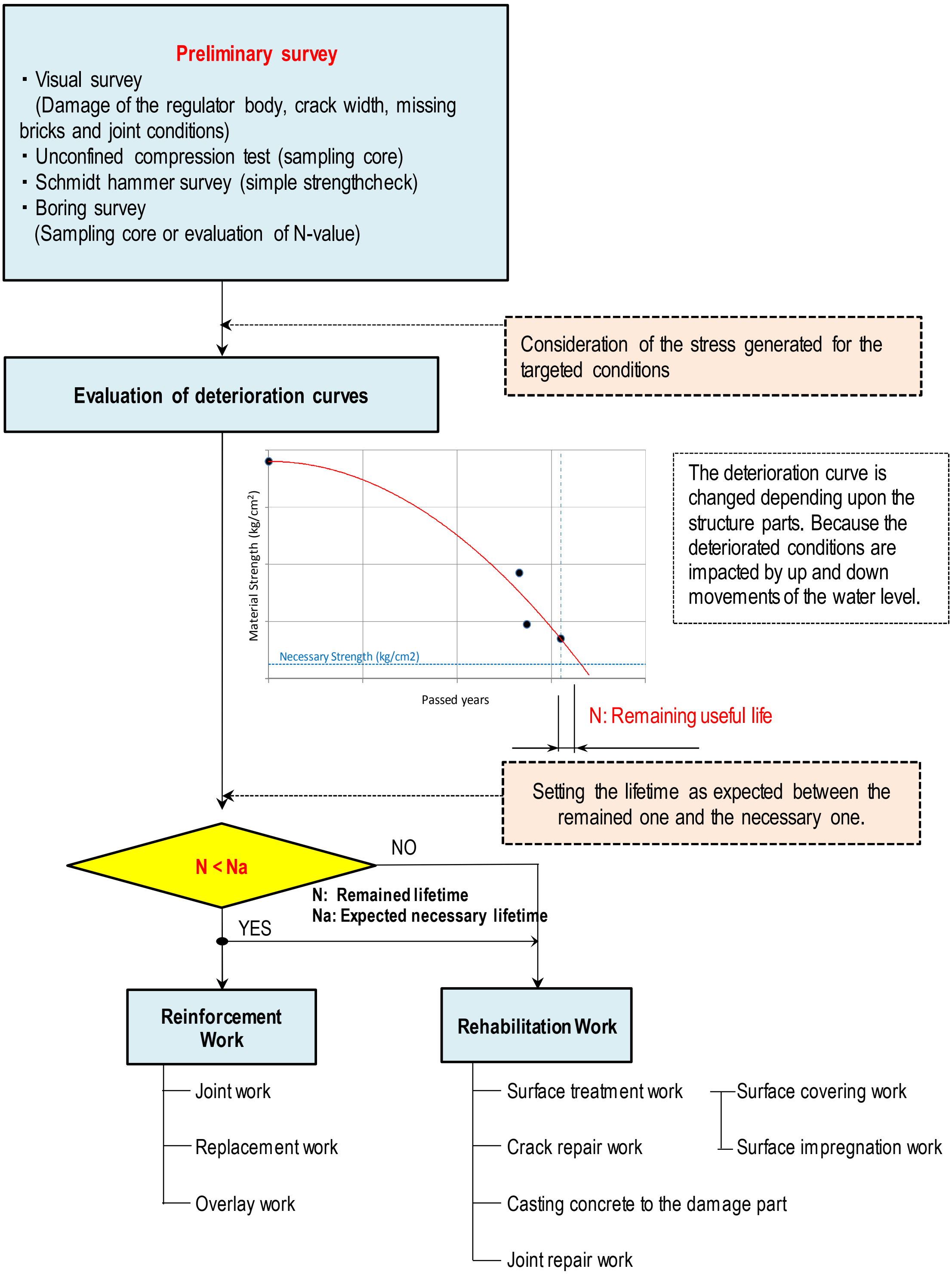

Preliminary survey
・Visual survey
(Damage of the regulator body, crack width, missing bricks and joint conditions)
・Unconfined compression test (sampling core)
・Schmidt hammer survey (simple strengthcheck)
・Boring survey
(Sampling core or evaluation of N-value)
Consideration of the stress generated for the targeted conditions
Evaluation of deterioration curves
Material Strength (kg/cm²)
Necessary Strength (kg/cm2)
Passed years
The deterioration curve is changed depending upon the structure parts. Because the deteriorated conditions are impacted by up and down movements of the water level.
N: Remaining useful life
Setting the lifetime as expected between the remained one and the necessary one.
N < Na
NO
N: Remained lifetime
Na: Expected necessary lifetime
YES
Reinforcement Work
Joint work
Replacement work
Overlay work
Rehabilitation Work
Surface treatment work
Surface covering work
Surface impregnation work
Crack repair work
Casting concrete to the damage part
Joint repair work

Figure 2-2. Flow of examination of appropriate measure works

2-4 Groundwater simulation analysis

(1) Purpose of analysis

The construction of NDGRs will result in a rise in canal water level, which induces rise in the groundwater level around the DGRs such as mosques, station, highways, buildings in the markets and resident area. There may be a serious concern of the damage of their structures, aggravating sanitary environment, the floating of buildings, and the deterioration of structure foundations, etc.

In this context, the aim of a groundwater simulation analysis is to predict and infer groundwater behavior after NDGRs construction, and to evaluate its environmental impact, and to provide data that is useful in deciding on the necessity and scale of mitigation measures.

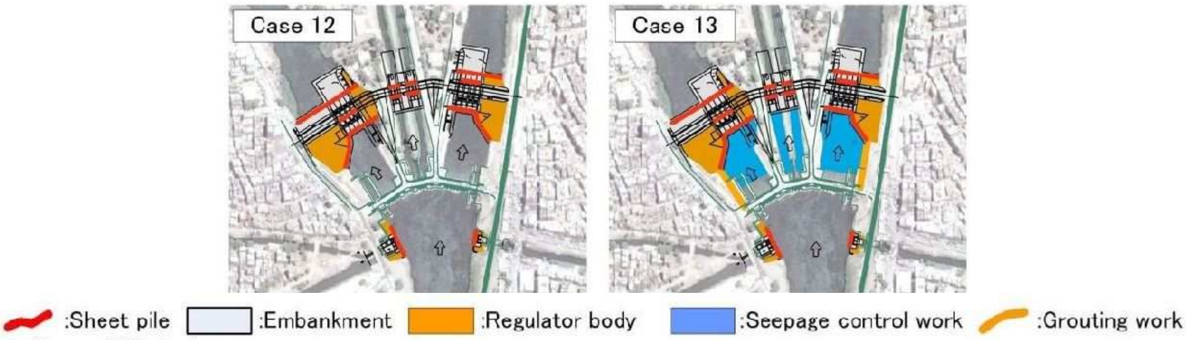
(2) Result of the analysis

The case 12 which takes sheet pile works, bank protection works and embankment works (proposed in the D/D study) restricts the risk of groundwater rise to surrounded foundation and underground structures with at most 0.3m rise in water level even beside the canals. As shown in Table 2-3, it was found that complete offset work is difficult even in the case with further seepage control works (case 13). Therefore, continuous monitoring work of groundwater and its analysis are recommended in addition to the improvement work of public sewage system to mitigate the groundwater rise caused by civilization.

Table 2-3 Simulation conditions and their results

Case	Condition					Result		
	Canal Water level	Sheet Pile	Embank ment	Seepage Control Work	Grouting	GW Rise	Inference Area	Increase in Seepage Amount
Case 12 (D/D design)	Plan	○	○	×	×	0.09m	300m (RB) 270m (LB)	39 m³/day
Case13 (Additional seepage control works)	ditto	○	○	○	○	0.06m	300m (RB) 290m (LB)	33 m³/day

Layout of seepage control works



Note: Peemeability is given as

Sheetpile: k–1.15x10^{-7} cm/sec x 1.25m thickness of wall(1 grid)
Embankment/Regulator body: k=1.15x10^{-6} cm/sec x beds' thickness underlain the stricter/embankment
Seepage Control works: k=1.15x10^{-5} cm/sec x beds' thickness underlain the stricter/embankment
Grounting: : k=1.15x10^{-5} cm/sec x 2.5 thichness of wall(1 grid)

3. Formulation of Integrated Water Management System

3-1 Target facilities to be covered with integrated water management system

In order to distribute irrigation water fairly and appropriately to the Project area, integrated water management system will be formulated for realizing wide area monitoring of irrigation water and water allocation plan. Each facility in the irrigation system consists of water diversion facilities, regulators, main canals, intakes for branch canals, branch canals, farm land and drainage canals.

In order to efficiently distribute water to 600,000 ha-irrigation area in accordance with irrigation system requirements, each facility must fulfill its function satisfactorily. The scope of integrated water management system shall be included the irrigation facilities on the main canals under the supervision of the GDWD in Assiut of MWRI and that of GDIs.

The target facility in water management covers the beginning facility of the main canal such as head regulator, the important facility for management along the main canal, and the branch canal intake with the large amount of water distribution from the main canal to the branch canal.

Table 3-1 Facilities targeted for monitoring (1/2)

Irrigation facilities			Name of the Target facilities		Number.
Regulator	Bahr Yusef canal		Dahab Regulator Sakoula Regulator Mazoura Regulator	Lahoun Regulator Abo El Shekok Regulator Regulator km39	6
	Ibrahimia canal		New Hafze Regulator Matay Regulator Maghagha Regulator	Sharahna Regulator El Gandy Regulator Ashmont Regulator	6
Branch canal	Bahr Yusef canal	Intake	Manshat EL Dahab El Hareka El Sabaa	Quftan Wesh El-Bab EL-Giza	6
		Weir	Hassan Wasef Weir		1
		Pump	New Kamdeer P.S. New Terfa P.S. Old Terfa P.S.	Old Sakoula P.S. Mazoura P.S.(2)	5
	Ibrahimia canal	Intake	Irad El Maharak El Kosia East Hafze West Hafze Adkak	Gendia Abo Shosha EL Soultany Tansa El Mansour	10
		Weir	Serry Weir	Maghagha Weir	2
Ibrahimia main canal			Ibrahimia Head Regulator		1
Lake			Quarun Lake		1
Total					38

Table 3-2 Facilities targeted for monitoring (2/2)

Irrigation facilities	Name of the Target facilities		Number
Dirout Group of Regulators	Bahr Yusef Regulator Ibrahimia Regulator Irad Delgaw Regulator Abo Gabal Regulator	Badraman Regulator Dairotiah Regulator Sahelyia Regulator	7
Total			7

3-2 Centralized management system

Remote monitoring of water level developed by the telemetry engineers and promoted by the CDT is expected to be utilized in the future following its wide dissemination because of its high expansibility and technical simplicity. Therefore, the CDT-based monitoring system shall be used continuously for the remote monitoring of the water levels at the regulators in the main canals, at the intakes of the branch canals, and for data processing that converts water levels into flow rate. The existing water management system is using the GPRS communication network system. The access point (APN), that is, the facility for implementing TCP/IP data transmission by GPRS communication, is managed by MWRI. The integrated water management system uses the same communication method and data transmission method in order to integrate with the current telemetry system, and uses the same facility of APN.

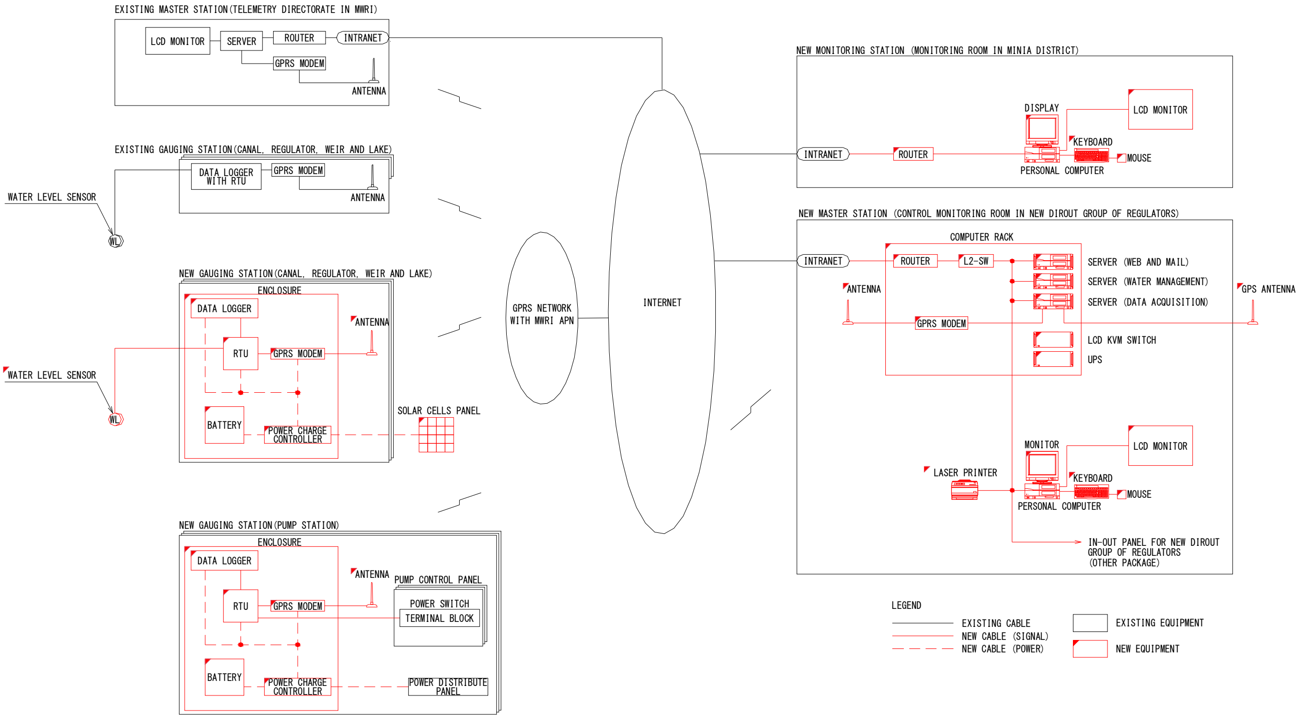


Figure 3-1 Integrated water management system composition of GPRS communication

3-3 Design of gauging station and master station

In the water level gauging station installed in the regulators or branch canal intakes, the water levels upstream and downstream of the gate are measured. The monitored water level is used for grasping the status of water distribution and future's proper gate operation.

The central monitoring station (master station) will be installed in the same building of the control house for NDGRs. The central monitoring office has a function to be collected, recorded and evaluated water level data at each gauging stations.

Table 3-3 Equipment of the gauging station

GPRS modem	Water level sensor	Protection pipe
RTU with Data logger	Enclosure	Frame of solar panel
Charge controller	Pole	Frame of enclosure
Battery	Foundation	Wiring cabel
Solar panel	Junction box	

Table 3-4 Equipment of the central monitoring station (master station)

GPRS modem	Web & E-mail server	19 inch Rack
Router	KVM Switch	Monitoring terminal
L2-SW	KVM Monitor	Laser printer
Data acquision server	Keyboard & Mouse	LCD Monitor
Water management server	UPS	

4. Construction Planning

4-1. Temporary Works

(1) Outline of the project

The construction site is located in an urban area, and the national railway and the national road run on the east and west sides, respectively, of the construction site. Both the temporary work plan and the construction plan were formulated using the field survey, the existing condition survey, and the construction equipment and materials survey, and take the actual conditions around the site into consideration.

The project consists of the following two components.

(a) Construction of the NDGRs 140 m downstream from the existing DGRs.

(b) Improvement of the communications facilities pertaining to the construction of the water distribution system.

Table 4-1. Outline of the project

Item	Structures
1) New Dirout Group of Regulators	
(a) Construction of new regulators	Construction work on six regulators
(b) Installation of gates	
Bahr Yusef	W 6.0 m × H 6.55 m, total 4 vents
Ibrahimia	W 6.0 m × H 6.55 m, total 4 vents
Abo Gabal	W 2.0 m × H 2.95 m, total 4 vents
Badraman	W 2.0 m × H 2.65 m, total 2 vents
Diroutiah	W 2.0 m × H 2.35 m, total 3 vents
Sahelyia	W 2.0 m × H 3.55 m, total 2 vents
(c) Improvement of peripheral facilities	Construction of maintenance bridge Improvement of retaining walls
(d) Cofferdam works	Single and double cofferdams of steel sheet pile
2) Integrated Water Management	
(a) Main canal gates management system (b) Branch canal intake management system (c) Establishment of integrated water management centre	Monitoring system installation work Monitoring system installation work Construction of centre building

Figure 4-1 shows the layout plan of temporary works.

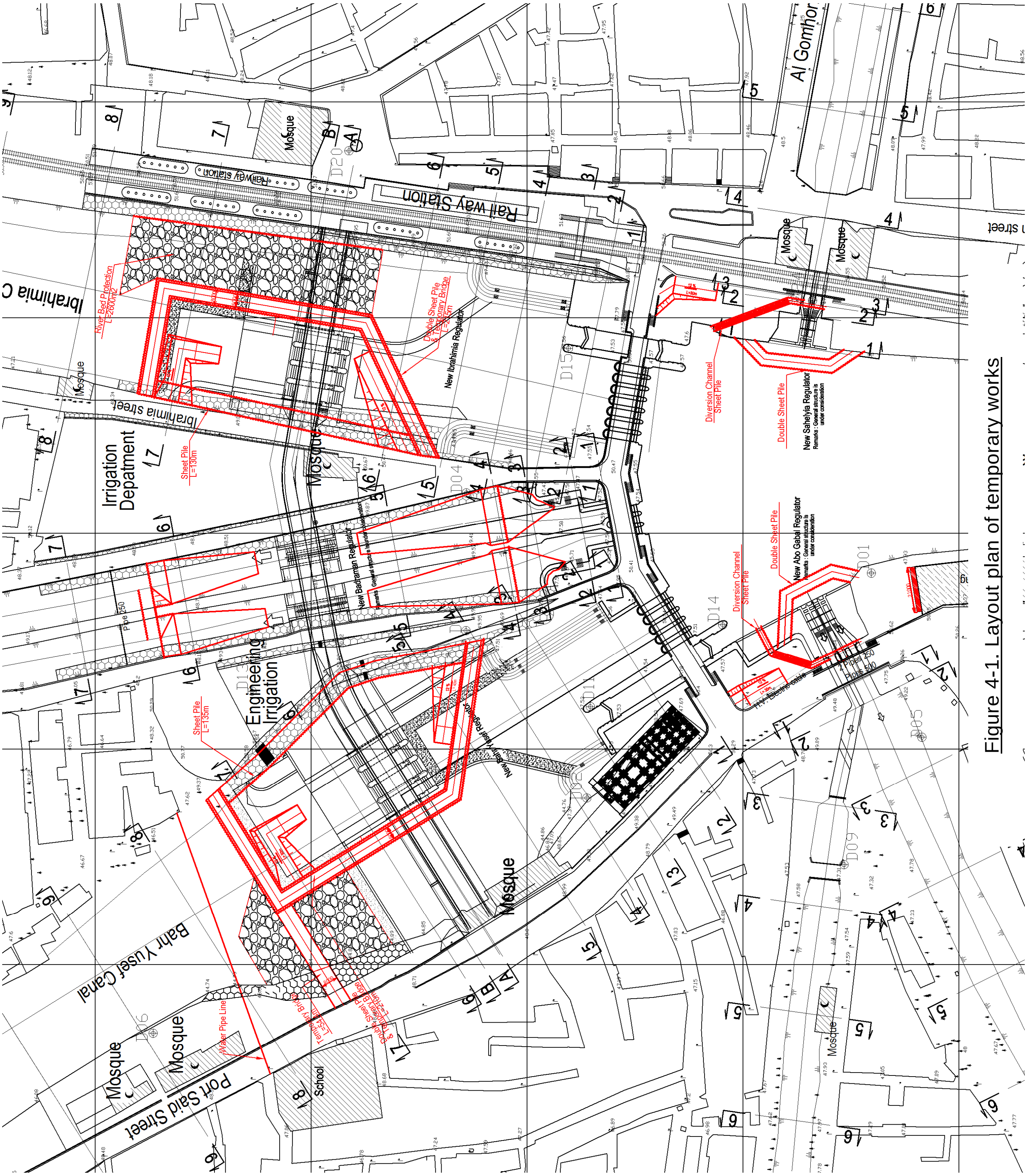


Figure 4-1. Layout plan of temporary works

4-2. Construction of the NDGRs and Water Management Facilities

In the construction of the NDGRs, the construction of Bahr Yusef regulator on the downstream side will begin first, and secondly the construction of Ibrahimia regulator will start. The construction of the other regulators, Badraman and Diroutiah, and on the upstream side, Abo Gabal and Sahelyia, will be performed in parallel with the construction of Bahr Yusef and Ibrahimia.
The construction flow of Bahr Yusef, Ibrahimia and the other regulators is as follows:

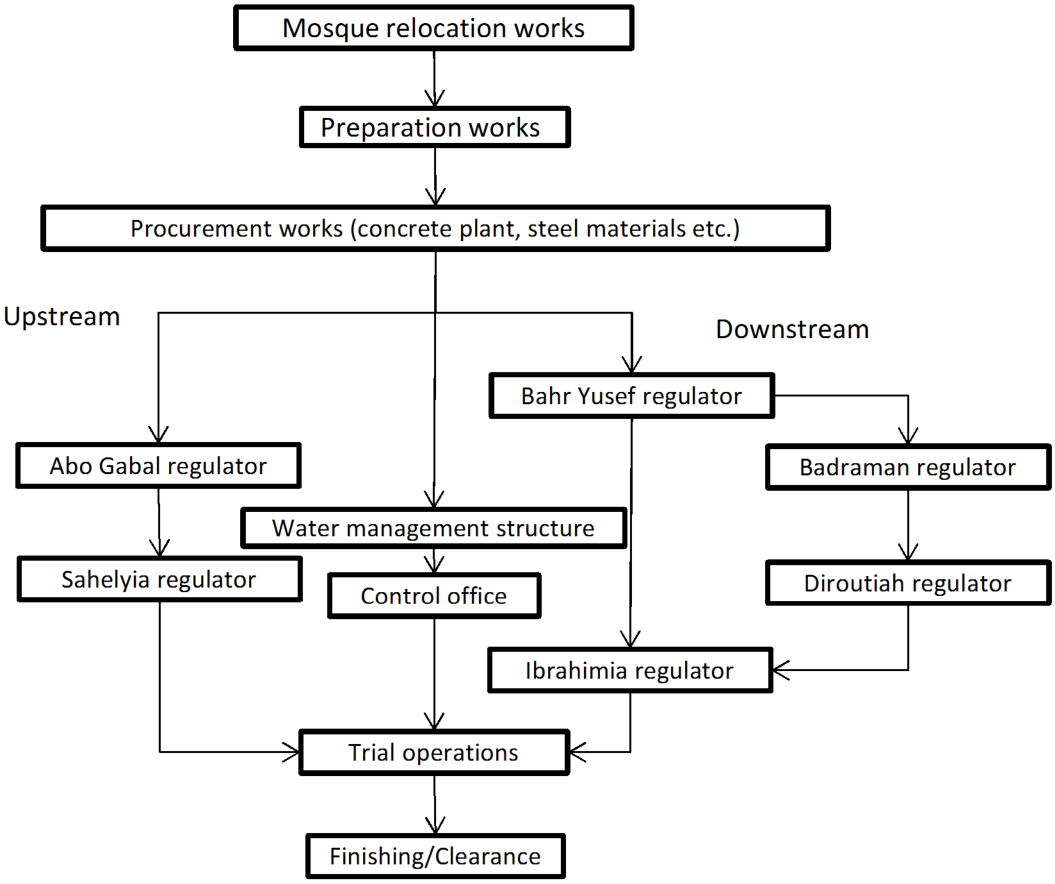


Figure 4-2. Regulator construction flow

The construction will start after the relocation of the mosque is completed by the Egypt side.
Preparation work → Temporary bridge → Double sheet coffer dam → Removal of existing facilities, Excavation inside site → Foundation piles and waterstop sheet piles → Construction of regulator structure → Installation of gates and trial operation → Removal of double sheet piles and switching diversion → Revetment work and appurtenant work (road works and electrical work) → Integrated trial operation/Operation training → Finishing/Clearing

The manufacture and transport of the gates, machinery and electrical equipment, the building work and the revetment work proceed in parallel with the construction of the structures and the installation and trial operation of the gate.

4-3. Work procedure

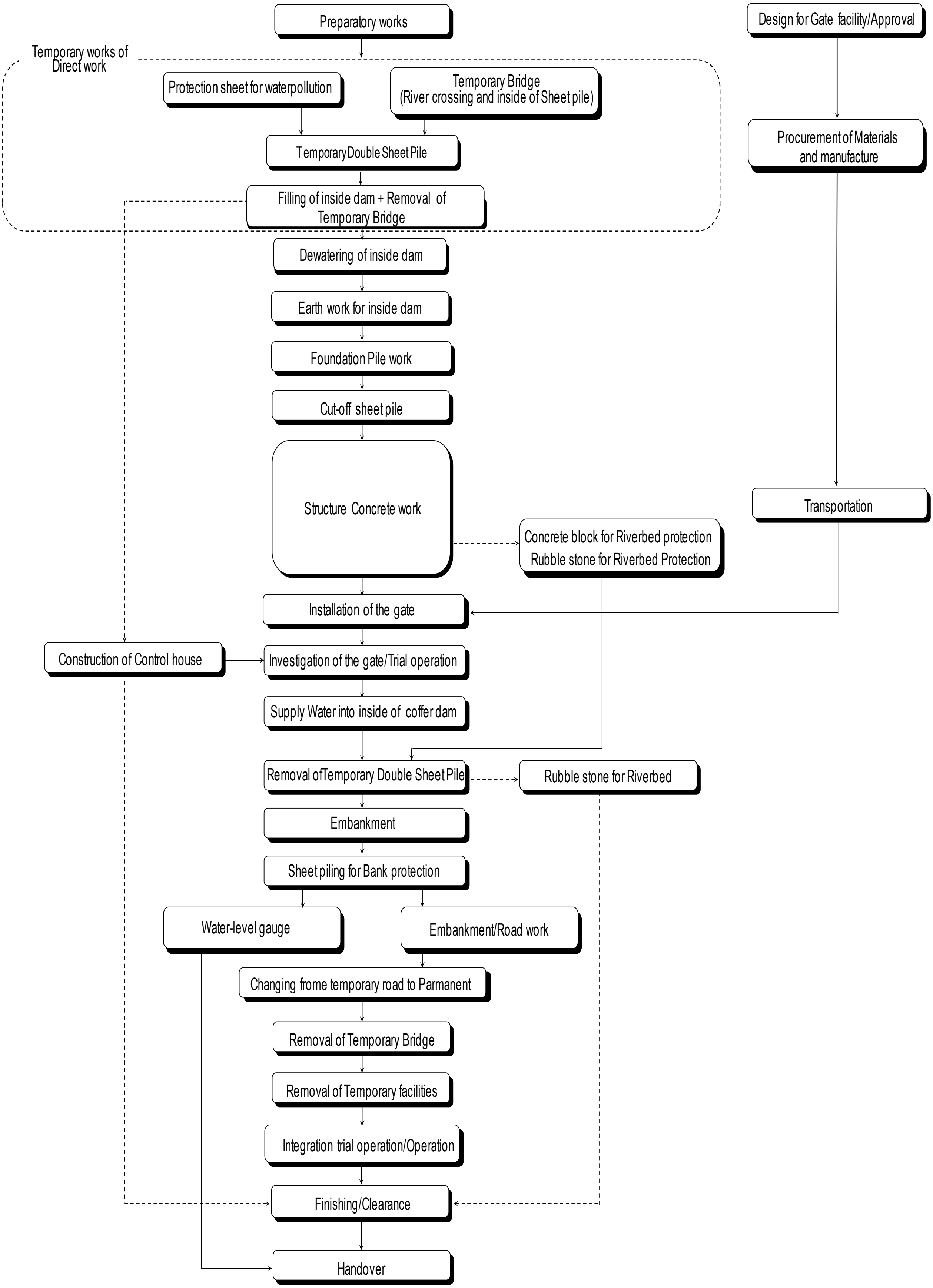
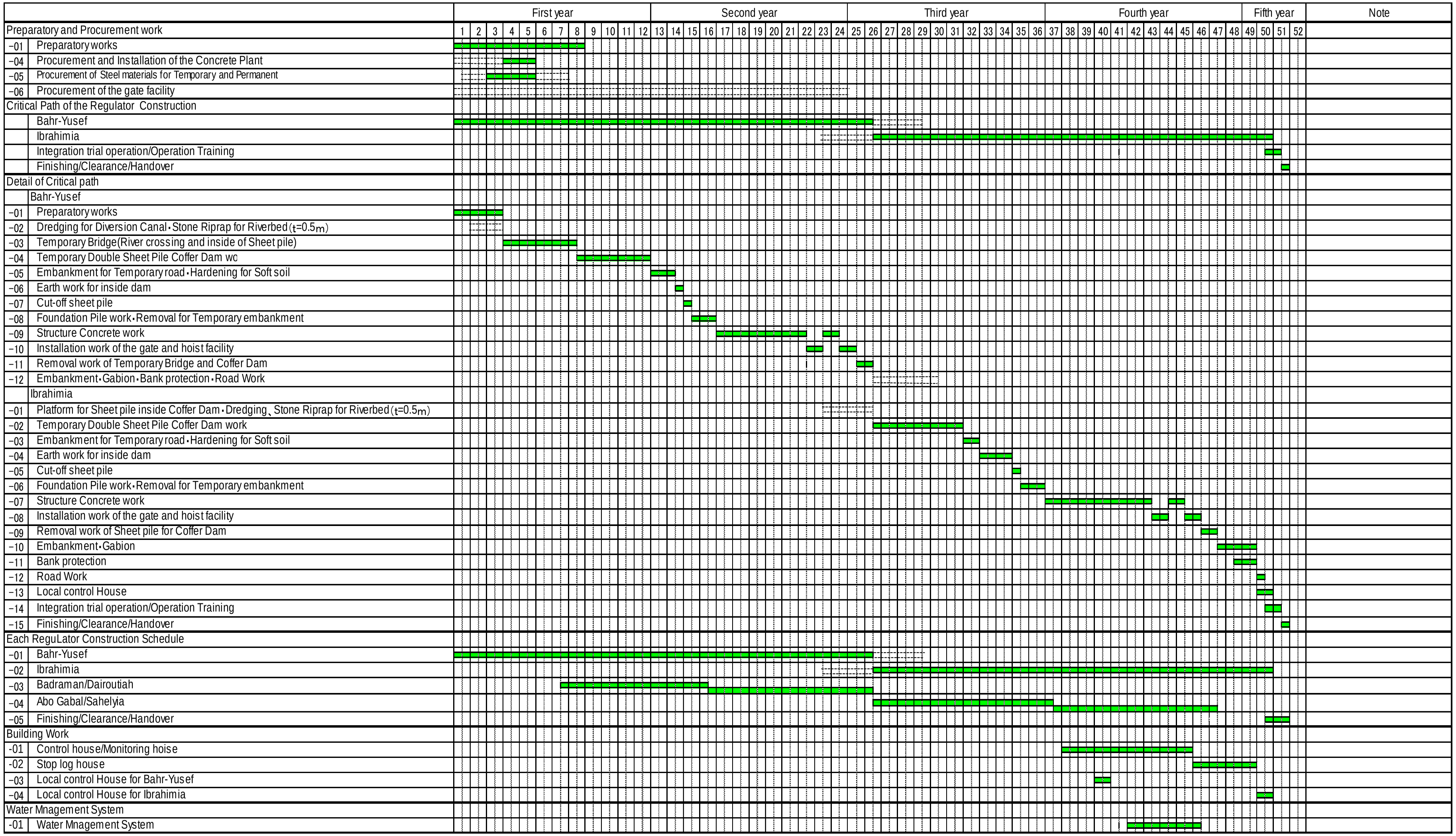

Preparatory works
Design for Gate facility/Approval
Temporary works of Direct work
Protection sheet for waterpollution
Temporary Bridge (River crossing and inside of Sheet pile)
TemporaryDouble Sheet Pile
Procurement of Materials and manufacture
Filling of inside dam + Removal of Temporary Bridge
Dewatering of inside dam
Earth work for inside dam
Foundation Pile work
Cut-off sheet pile
Structure Concrete work
Transportation
Concrete block for Riverbed protection
Rubble stone for Riverbed Protection
Installation of the gate
Construction of Control house
Investigation of the gate/Trial operation
Supply Water into inside of coffer dam
Removal ofTemporary Double Sheet Pile
Rubble stone for Riverbed
Embankment
Sheet piling for Bank protection
Water-level gauge
Embankment/Road work
Changing frome temporary road to Parmanent
Removal of Temporary Bridge
Removal of Temporary facilities
Integration trial operation/Operation
Finishing/Clearance
Handover

Figure 4-3. Work procedure

4-4. Construction schedule

Table 4-2. Construction schedule (large regulators)



Preparatory and Procurement work	
-01	Preparatory works
-04	Procurement and Installation of the Concrete Plant
-05	Procurement of Steel materials for Temporary and Permanent
-06	Procurement of the gate facility
Critical Path of the Regulator Construction	
	Bahr-Yusef
	Ibrahimia
	Integration trial operation/Operation Training
	Finishing/Clearance/Handover
Detail of Critical path	
	Bahr-Yusef
-01	Preparatory works
-02	Dredging for Diversion Canal･Stone Riprap for Riverbed (t=0.5m)
-03	Temporary Bridge(River crossing and inside of Sheet pile)
-04	Temporary Double Sheet Pile Coffer Dam wo
-05	Embankment for Temporary road･Hardening for Soft soil
-06	Earth work for inside dam
-07	Cut-off sheet pile
-08	Foundation Pile work･Removal for Temporary embankment
-09	Structure Concrete work
-10	Installation work of the gate and hoist facility
-11	Removal work of Temporary Bridge and Coffer Dam
-12	Embankment･Gabion･Bank protection･Road Work
	Ibrahimia
-01	Platform for Sheet pile inside Coffer Dam･Dredging､Stone Riprap for Riverbed (t=0.5m)
-02	Temporary Double Sheet Pile Coffer Dam work
-03	Embankment for Temporary road･Hardening for Soft soil
-04	Earth work for inside dam
-05	Cut-off sheet pile
-06	Foundation Pile work･Removal for Temporary embankment
-07	Structure Concrete work
-08	Installation work of the gate and hoist facility
-09	Removal work of Sheet pile for Coffer Dam
-10	Embankment･Gabion
-11	Bank protection
-12	Road Work
-13	Local control House
-14	Integration trial operation/Operation Training
-15	Finishing/Clearance/Handover
Each RleguLator Construction Schedule	
-01	Bahr-Yusef
-02	Ibrahimia
-03	Badraman/Dairoutiah
-04	Abo Gabal/Sahelyia
-05	Finishing/Clearance/Handover
Building Work	
-01	Control house/Monitoring hoise
-02	Stop log house
-03	Local control House for Bahr-Yusef
-04	Local control House for Ibrahimia
Water Mnagement System	
-01	Water Mnagement System

Table 4-3 Construction schedule (small regulators)

		First year												Second year												Third year												Fourth year												Fifth year				Note
Detail of Critical path for Small Regulator		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
	Badraman																																																					
-01	Preparatory works・Temporary Embankment for Coffer Dam・Steel Sheet Pile							🟩	🟩																																													
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile								🟩	🟩																																												
-03	Structure Concrete work									🟩	🟩	🟩	🟩	🟩																																							
-04	Installation work of the gate and hoist facility												🟩	🟩	🟩																																						
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile															🟩																																					
-06	Road Work・Trial Operatio																🟩																																				
	Diroutiah																																																					
-01	Preparatory works・Temporary Embankment for Coffer Dam・Steel Sheet Pile																🟩	🟩																																			
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																	🟩	🟩																																		
-03	Structure Concrete work																		🟩	🟩	🟩	🟩	🟩	🟩																													
-04	Installation work of the gate and hoist facility																						🟩	🟩	🟩																												
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																								🟩	🟩																											
-06	Road Work・Trial Operation																										🟩																										
	Abo Gabal																																																					
-01	Preparatory works・Embankment for Access Road・Sheet pile for Coffer Dam & Temporary Canal																										🟩	🟩																									
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																												🟩																								
-03	Structure Concrete work																													🟩	🟩	🟩	🟩	🟩	🟩																		
-04	Installation work of the gate and hoist facility																																	🟩	🟩	🟩																	
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																			🟩	🟩																
-06	Trial Operation																																					🟩															
	Sahelyia																																																				
-01	Preparatory works・Embankment for Access Road・Sheet pile for Coffer Dam & Temporary Canal																																					🟩	🟩														
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																																							🟩													
-03	Structure Concrete work																																								🟩	🟩	🟩	🟩	🟩								
-04	Installation work of the gate and hoist facility																																													🟩							
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																													🟩	🟩						
-06	Trial Operation																																															🟩					
	Water Management System																																																					
	Civil works																																																					
-01	Assiut (4 sites)																																										🟩											
-02	West Minia (6 sites)																																										🟩	🟩										
-03	East Minia (8 sites)																																										🟩	🟩										
-04	Beni suef and Fayoum (8 sites)																																										🟩	🟩										
	Electrical works																																																					
-01	Master station (Dirout)																																												🟩	🟩								
-02	Monitoring station (Minia)																																												🟩	🟩								
-03	Assiut (4 sites)																																												🟩									
-04	West Minia (6 sites)																																												🟩	🟩								
-05	East Minia (8 sites)																																												🟩	🟩								
-06	Beni suef and Fayoum (8 sites)																																												🟩	🟩								
-07	Software development in cairo																																		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦										
-08	Commissioning test																																														🟩						

5. Project Cost Estimation

5-1. Criteria and manual of project cost estimation

(1) Time of cost estimation January 2017

(2) Expected commencement date February 2018

(3) Exchange rate the average rate for the three months from February to April 2017

1USD = ¥113.34, 1EUR = ¥121.26, 1LE = ¥6.49

(4) Indirect cost

- Indirect cost for Civil and Temporary Works : 35% of each direct cost
- Indirect cost for Gate Manufacture : 3% of the direct cost

(5) Unit price of manpower, materials, and rental fee of heavy equipment etc.

- Procured from Japan: 90% of the average price between two books for monthly unit price published in Japan. When there was any item not described on the two books, competitive estimations from three companies were applied.
- Procured in Egypt: 100% of the average price of the competitive estimations from three companies

(6) Price escalation

- Price escalation rate for LC :
  total ratio is 18.9% (17.2% of recent price escalation + 1.0% per year during construction)
- Price escalation rate for FC :
  total ratio is 4.2% (1.6% per year during construction)

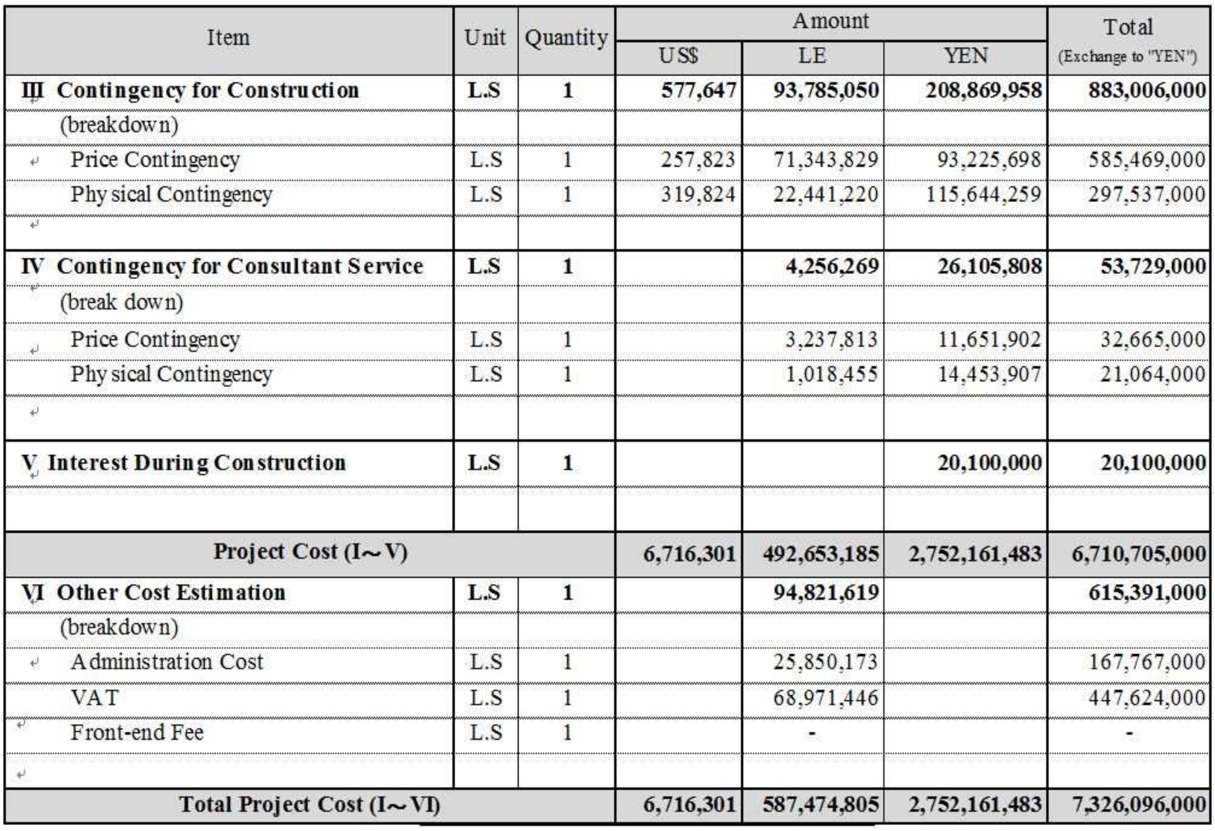
(7) Depreciation ratio for temporary steel material 50%

5-2. Estimation of the project cost

Table 5-1. Construction and project cost estimation (1/2)

Item	Unit	Quantity	Amount			Total
			US$	LE	YEN	(Exchange to "YEN")
I Construction Cost	**L.S**	**1**	**6,138,654**	**377,480,579**	**2,219,659,487**	**5,365,263,000**
(breakdown)						
A. Civil Works	L.S	1	1,422,252	213,048,447	1,870,904,765	3,414,787,000
B. Temporary works	L.S	1	4,309,402	117,144,168	348,754,722	1,597,447,000
C. Building works	L.S	1		4,589,565		29,786,000
D. Integrated Water Management System	L.S	1		42,698,399		277,112,000
E. Dispute Board	L.S	1	407,000			46,129,000
II Consultant Service	**L.S**	**1**		**17,131,288**	**277,426,230**	**388,607,000**

Table 5-2. Construction and project cost estimation (2/2)



Item	Unit	Quantity	Amount			Total
			US$	LE	YEN	(Exchange to "YEN")
Ⅲ Contingency for Construction	**L.S**	**1**	**577,647**	**93,785,050**	**208,869,958**	**883,006,000**
(breakdown)						
Price Contingency	L.S	1	257,823	71,343,829	93,225,698	585,469,000
Physical Contingency	L.S	1	319,824	22,441,220	115,644,259	297,537,000
Ⅳ Contingency for Consultant Service	**L.S**	**1**		**4,256,269**	**26,105,808**	**53,729,000**
(break down)						
Price Contingency	L.S	1		3,237,813	11,651,902	32,665,000
Physical Contingency	L.S	1		1,018,455	14,453,907	21,064,000
Ⅴ Interest During Construction	**L.S**	**1**			**20,100,000**	**20,100,000**
Project Cost (Ⅰ～Ⅴ)			**6,716,301**	**492,653,185**	**2,752,161,483**	**6,710,705,000**
Ⅵ Other Cost Estimation	**L.S**	**1**		**94,821,619**		**615,391,000**
(breakdown)						
Administration Cost	L.S	1		25,850,173		167,767,000
VAT	L.S	1		68,971,446		447,624,000
Front-end Fee	L.S	1		-		-
Total Project Cost (Ⅰ～Ⅵ)			**6,716,301**	**587,474,805**	**2,752,161,483**	**7,326,096,000**

Table 5-3 the Ratio for STEP Loan

Item	Grade	Detail	Unit	Quantity	Amount
A-11. Gate manufactures and works					
1. Gate manufacture	gate leaf	6.0×6.55	L.S	2.0	324,769,300
	gate guide		L.S	2.0	272,305,220
	hoisting device	hydraulic	L.S	2.0	846,320,100
	remote operation system		L.S	2.0	228,439,580
1. Installation for manufactures	Japanese mechanical enginee		day	1,050.0	31,403,295
	Japanese electrical engineer f		day	1,050.0	35,009,415
sub-total					1,738,246,910
A-12. Expense of the machine and facilities					
1. Rent fee for heavy equipment	2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0	42,926,895
sub-total					42,926,895
B-1. Temporary Coffer Dam					
1. Double sheet pile	14). Japanese sheet pile opera		day	2,190.0	79,914,195
sub-total					79,914,195
B-8. Transportation / Shipment					
	B-8-13. packing	951.0 F/T	L.S	1.0	12,754,883
	B-8-14. loading		L.S	1.0	7,095,825
	B-8-15. ocean transpotation		F/T	951.0	26,190,947
sub-total					46,041,655
Total					1,907,129,655

Ratio of the goods and services to be procured from Japan

1) Construction Cost 5,365,263 10^3 YEN

2) Cost of the goods and services to be procured from Japan 1,907,130 10^3 YEN

2)／1)＝ 35.5% ＞30%

6. Draft Bidding Documents

6-1. Contents of Works for the Preparation of Bidding Documents

6-1-1. Regulation and framework of procurement of public works in the Egyptian government

In Egypt, procurement of public works is made based on the Law No.89 of 1998 and its implementation regulations (Ministerial Decree No. 1367 of 1998), commonly referred to as "Tenders Law". Based on this law, executing agencies of public works prepare bidding documents, and execute pre-qualification, tendering and evaluation, and contract negotiations and signing.

According to the assessment of the procurement process of public works in Egypt, in the "Public Procurement Sector Assessment -Review of Laws and Practice in the SEMED Region," which was published by EBRD in 2013, there is no independent authority to handle claims related to public works, and there is also no single entity to formulate policies and execute government procurement process/procedures, even though transparency and efficiency are somewhat secure.

6-1-2. Differences between the regulations of the Egyptian government and JICA's guidelines for procurement under Japanese ODA Loans

At the early stage of works and discussions for the preparation of draft Bidding Documents for NDGRs project, the differences between laws and regulations related to procurement in Egypt and JICA's Procurement Guideline (*Handbook: Guideline for Procurement under Japanese ODA Loans* April 2012) were discussed (Refer to Table 1-2.1 of main report of "Vol. IV DRAFT BIDDING DOCUMENTS".)

In Article 4.7 of the Minutes of Discussions dated 21 May 2014 on the Loan Agreement for NDGRs, it was agreed that JICA Guidelines shall be applied for the procurements in this project. While JICA Guideline shall prevail, requests from RGBS to follow the Egyptian laws were also reflected in the documents as much as possible.

6-2. Preparation of Draft Bidding Documents

6-2-1. Contents of draft bidding documents

At the early stage of the preparation works on the draft Bidding Documents, RGBS made request to JICA to change the procurement process so as to combine the pre-qualification and bidding process to be made simultaneously, and bidding documents shall be made as "PQ-embedded bidding documents". This request was based on their intention to shorten the procurement process on the civil works contract. The team considered this issue as appropriate request, however the final decision shall be made by the direct discussion between RGBS and JICA. Under such circumstance, two patterns of draft Bidding Documents (PQ-embedded Documents, and separated PQ/Bidding Documents) were prepared, however discussions thereafter were made basically on PQ-embedded Documents.

For this issue, RGBS requested the study team to maintain both patterns for the decision in future. Therefore, PQ embedded Documents are adopted as the final product as part of the Final Report, and separated PQ/Bidding Documents are also submitted but only in electric file.

6-2-2. Contents of discussions and understanding with Egyptian side on draft Bidding Documents (except technical specifications)

The contents of discussions during ‘8th Assignment’ and ‘9th Assignment’ on the draft Bidding Documents, including initial presentation from the team, comments from RGBS, information from JICA Egypt Office, conclusion as of 24 February, comments from JICA thereafter, and conclusion as of 24 April, were summarized in Table 2-2.1 of the main report “Vol. IV DRAFT BIDDING DOCUMENTS”.

After the completion of ‘9th Assignment’, final comments were provided by RGBS on 10 May 2017 and by JICA on 19 May 2017. By reflecting these comments, the draft Bidding Documents were finalized as part of the Final Report of the Study. The summary of said comments and reflection on the final draft Bidding Documents are summarized in Table 2-2.2 of the main report “Vol. IV DRAFT BIDDING DOCUMENTS”.

6-2-3. Draft bidding documents (technical specifications)

As for the technical specifications, an integral part of draft Bidding Documents, discussions with RGBS were started on ‘8th Assignment’ in February 2017. After the confirmation of structure and contents, actual works on the preparation of technical specifications were started.

The contents of technical specifications are as follows:

1) General Provisions

2) General Technical Specifications

    - Civil Works
    - Mechanical and Electrical Works

3) Particular Technical Specifications

    - Civil Works
    - Mechanical and Electrical Works

For the preparation of technical specifications, attentions were paid on the consideration of fair risk allocation among contract parties, and also consistency with contents of general conditions of contract.

7. Environmental and Social Consideration

During the F/S of the Project in 2010, the EIA Report was prepared and it was approved by EEAA in the same year. The Report mentions the environmental monitoring in pre-construction stage, however, the monitoring implementation organization is not specified. Therefore, this matter was discussed at the 25th TAC Meeting, and it was concluded that the S/V consultant will be in charge of monitoring in the stage, which means that it is necessary to add the monitoring activities to the current TOR of the S/V consultant. On the other hand, environmental monitoring in construction stage and operation stage are to be done by the contractor and MWRI, respectively.

As a result of review of the EIA Report, some of the monitoring items are to be clarified or modified. According to EEAA, it is not needed to get re-approval of the EIA Report, as far as the project components, scale of the structures, location and so on are not changed, and the EIA Report of the Project is still effective. In addition, if necessary, it is possible to modify the proposed environmental monitoring items and methods, under the condition that the reason for the modification is described. Still, it is noted that monitoring groundwater level and groundwater quality shall be implemented since the approval letter of the EIA report mentions the necessity of the monitoring of those items.

The Environment WG reviewed and examined the EIA report, focusing on the Environmental Evaluation, Environmental Management Plan and Monitoring Plan. According to realistic probability and necessity, some monitoring items are cancelled or added with those reasons. Moreover, frequency, sampling points, methodologies of monitoring and implementation organization are clarified through the discussion among the WG members.

As a point of concern in terms of environmental and social consideration, mosque transfer is planned for the Project implementation. There are three affected mosques that are requested to be resettled. New locations of the two mosques out of them, which are under control of the Ministry of Awqaf, have been fixed, and they will be relocated prior to the construction works. On the other hand, the last mosque, under the management of MWRI, is planned to be shifted within the area owned by MWRI in the construction stage. It is needed to monitor whether the transfer of those mosques is implemented as planned.

The groundwater monitoring results indicates that groundwater levels are significantly influenced by change of the water levels of Bahr Yusef canal and Ibrahimia canal. It is, therefore, necessary to monitor change of the groundwater level continuously, especially, those of BH-N10, BH-N11, BH-N12 and BH-N13, which correspond to the change of water level of the canals. Furthermore, the total (fecal) coliform was detected in the groundwater, and the cause is probably seepage from the sewage. Therefore, it is needed to improve current sewage treatment system.

Through of the Project implementation, it is proposed to establish the Security Management Committee, which coordinates, assesses various issues to maintain security of the project. It is proposed that the committee consists of RGBS staff of Dirout and Cairo, S/V consultant and the Contractor. Proposed major tasks of the committee are; 1) supervision of monitoring and examination of monitoring result, 2) taking measures if some problems are identified, 3) handling of complaints from the people, 4) Identification and counting of those who catch fish around the Dirout Regulators and their legalities, and taking measures, and 5) reporting, recording and information sharing, especially, any issues identified and measured taken.

8. Mathematical Model Analysis

8-1. Water Surface Profile Analysis

(1) Objectives of Analysis

The objective is to calculate the water surface profile impacted by the construction of NDGRs in order to check the discharge ability of the Ibrahimia canal. The analysis is conducted by one-dimensional unsteady flow analysis using the Ibrahimia canal cross-section given in measurement results.

(2) Result of Analysis

Given by 0.20m increase of water level at the existing DGRs due to the new operation water level of the NDGRs, the water surface profile is impacted to the D.S. of Ibrahimia intake from the existing DGRs. The difference between water levels, however, is only 0.05 m at the upstream. Therefore, it was found that there is no large impact to the operation of the Ibrahimia intake besides the discharge capacity of the Ibrahimia canal is enough in the new conditions (new water level and new discharge volume) to the NDGRs.

8-2. Mathematical Model Analysis

(1) Objectives of Analysis

Since the NDGRs is required to divert accurately and stably the water to the seven main canals through the five regulators, those regulators should be secured for the necessary hydraulic function and capability. In order to clarify those capabilities, the mathematical model is applied. The sediment and the scouring phenomena around the NDGRs, furthermore, should be analyzed based on the result of the flow conditions analysis taken into consideration the gate operation by overflow and underflow.

In this report, the former analysis is regarded as the "Flow Analysis" and another is regarded as the "Riverbed Variation Analysis". As for the riverbed analysis, the present available data is utilized for the analysis. The followings show the result of analysis.

(2) Result of Analysis

- Flow Analysis

  It was found that the five regulators of the NDGRs have enough capability to divert to the seven canals properly. Under the conditions of existing canal sections, the maximum velocity on the bottom layer around the D.S. of the NDGRs is 0.8~1.0 m/s in the Bahr Yusef canal and 0.8 m/s in the Ibrahimia canal. As for the analysis to the planned canal sections, some uneven tendencies are observed among each vent in the distribution velocity of the new Ibrahimia regulator, but all of those are less than the allowable velocity (Va=2.00 m/sec). Accordingly, there is no hydraulically serious problem to the NDGRs.

- Riverbed Variation Analysis

  There is the tendency of sedimentation between the existing DGRs and the NGDRs due to the low water velocity. As for new Abo Gabal and Sahelyia regulators which are located on the U.S of existing regulators, the sedimentation around the new intake tend to decrease after NDGRs construction, but still remains the same tendency. Accordingly, the removal works to the sedimentation should be maintained periodically as maintenance works after the construction of NDGRs.

8-3. Integrated Evaluation of Hydraulic Model Test

(1) Objectives of Integrated Evaluation

As for the physical hydraulic model test conducted by HRI according to the contract with MWRI, the test condition should have the consistency with the mathematical analysis conducted by the D/D consultants in the test conditions. In this context, the objective is to organize and adjust the conditions between the physical hydraulic model test and mathematical model analysis by providing the information and advice on the hydraulic model experiments.

The target of the evaluation in this report is the 3D physical hydraulic model test for the flow condition in the vicinity of the NDGRs and the 2D physical hydraulic model test for the river bed protection of NDGRs.　The evaluations are targeted for the two tests above.

(2) Result of Integrated Evaluation

As a result of consideration based on the recommendation of the physical hydraulic model test, the following recommendations are applied to the design of the NDGRs.

3D physical hydraulic model test

As a result of the 3D physical hydraulic model test, the embankment bank protection should be done at the D.S. of the left bank of the new Bahr Yusef regulator and the D.S. of the right bank of the new Ibrahimia regulator in order to alleviate the stagnant area (with slow vortex current)

2D physical hydraulic model test

As a result of the 2D physical hydraulic model test, the following design specification are identified and applied to the design of the NDGRs.

1）Length of bed protection
  - ✓ Large regulators (Bahr Yusef and Ibrahimia) : 30m
  - ✓ Small regulators (Badraman): 15m
  - ✓ Small regulators (Abo Gabal and Sahelyia) : no need

2）Type of bed protection
  - ✓ Ripraps

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Volume Ⅳ Draft Bidding Document

Volume Ⅴ Environmental and Social Consideration

Volume Ⅵ Mathematical Model Analysis

Volume Ⅶ Recommendations

Appendix (1/3)

A. Design of Regulators
B. Water Management System
C. Quantity Calculation Sheets
D. Construction Planning

Appendix (2/3)

E. Cost Estimation
F. Environmental and Social Consideration
G. Mathematical Model Analysis
H. Minutes of Discussions

Appendix (3/3)

I. Drawings

Abbreviations

ADCP	: Acoustic Doppler Current Profiler
APN	: Access Point Name
ASTM	: American Society for Testing and Materials
BC	: Boundary Condition
BH	: Borehole
B/D	: Basic Design
CDSSD	: Central Directorate of Studies, Specifications and Designs
CDT	: Central Directorate for Telemetry
CDWD	: Central Directorate of Water Distribution
CRI	: Construction Research Institute
D/D	: Detailed Design
DGRs	: Dirout Group of Regulators
DO	: Dissolved Oxygen
DS	: Downstream
EBRD	: European Bank for Reconstruction and Development
EC	: Electric Conductivity
ECRI	: Environmental and Climate changes Institute
EEAA	: Egyptian Environment Affairs Agency
EGSA	: Egyptian General Survey Authority
EIA	: Environmental Impact Assessment
EL	: Elevation
EMP	: Environmental Management Plan
EMoP	: Environmental Monitoring Plan
ENR	: Egyptian National Railway Authority
FC	: Foreign Currency
FDM	: Finite Difference Method
FHT	: Falling Head Test
F/S	: Feasibility Study
GDIs	: General Directorates of Irrigations
GDWD	: General Directorate for Water Distribution
GPRS	: General Packet Radio Service
GPS	: Global Positioning System
GW	: Groundwater
HAD	: High Aswan Dam
HCWW	: Holding Company for Water & Wastewater
HD	: High Definition
HPPEA	: Hydro Power Plant Executive Authority
H-Q	: Height-Quantity
HRI	: Hydraulic Research Institute
ID	: Irrigation Department
IIS	: Irrigation Improvement Sector
IMF	: International Monetary Fund
IP	: Internet Protocol
KfW	: Kreditanstalt für Wiederaufbau (German government-owned development bank)
KVM	: Keyboard, Video, Mouse

JICA : Japan International Cooperation Agency
JIS : Japanese Industries Standards
L2SW : Layer 2 Switch
LC : Local Currency
LCD : Liquid Crystal Display
LE : Livre Égyptienne (Egyptian Pound)
LLT : Lateral Load Test
MCCB : Molded Case Circuit Breaker
MD : Minutes of Discussion
MED : Mechanical and Engineering Department
MEE : Ministry of Electricity and Energy
MERE : Ministry of Electricity & Renewable Energy
MMA : Mathematical Model Analysis
MOT : Ministry of Transport
MWRI : Ministry of Water Resources and Irrigation
N : Number of Blows (value for SPT)
NDGRs : New Dirout Group of Regulators
NTP : Network Time Protocol
NWRC : National Water Research Center
ODA : Official Development Assistance
O&M or O/M : Operation and Maintenance
pH : Potential Hydrogen
PHMT : Physical Hydraulic Model Test
PIU : Project Implementation Unit
PQ : Prequalification
Q3D : Quasi-3 Dimensional
RC : Reinforced Concrete
RD : Record of Discussion
RGBS : Reservoirs and Grand Barrages Sector
RTA : River Transfer Authority
RTU : Remote Terminal Unit
SCADA : Supervisory Control and Data Acquisition
SEMED : Southern and Eastern Mediterranean
SMC : Security Management Committee
SPT : Standard Penetration Test
STEP : Special Terms for Economic Partnership
TAC : Technical Advisory Committee
TBM : Temporary Benchmark
TCP : Transmission Control Protocol
TDS : Total Dissolved Solids
TSS : Total Soluble Salts
UNESCO : United Nations Educational, Scientific and Culture Organization
US : Upstream
VAT : Value Added TAX
VGA : Video Graphics Array
WG : Working Group
WL : Water Level

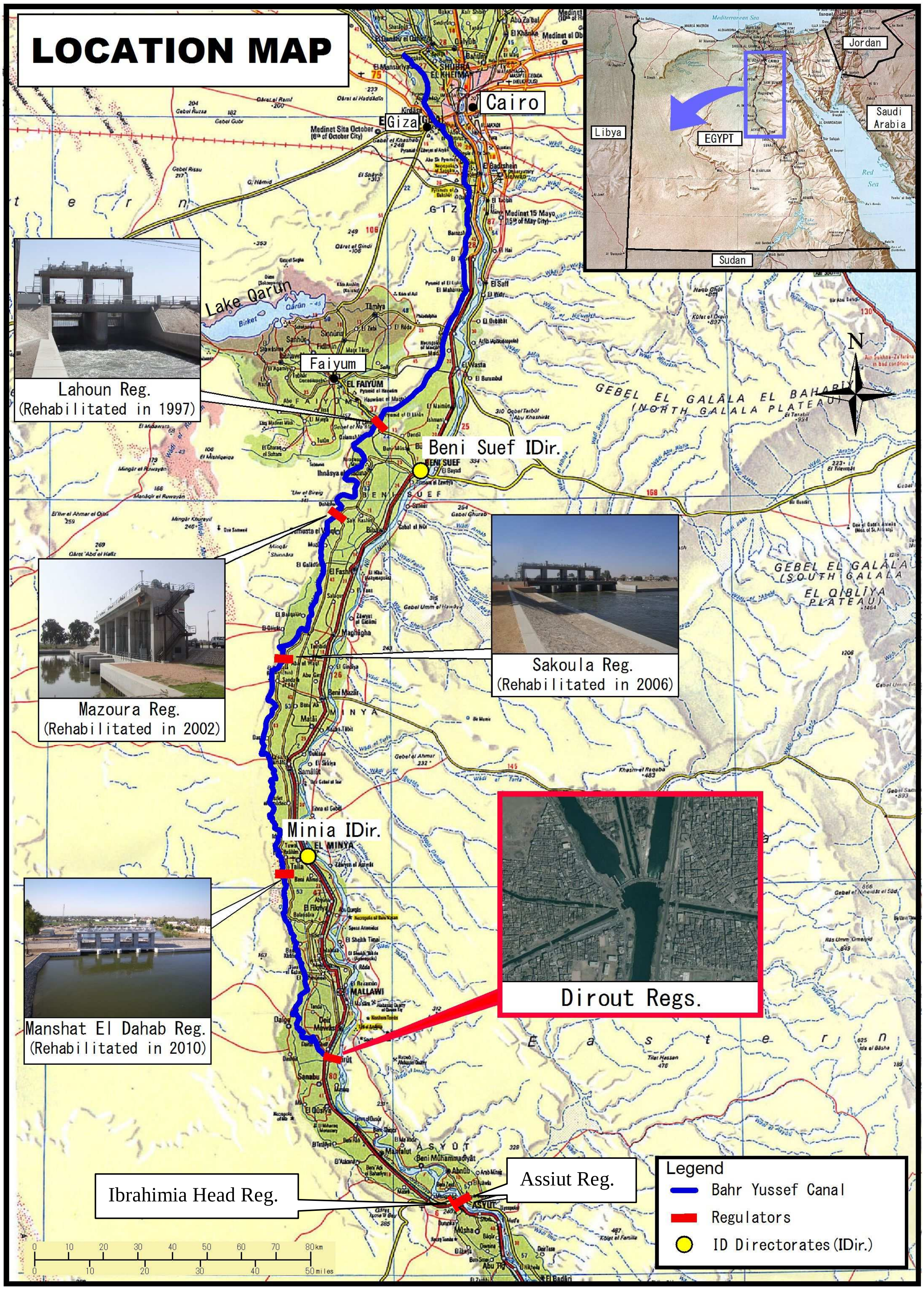
Unit

BCM	: billion cubic meter	ℓ	: liter
cm	: centimeter	lb	: pound
fed	: feddan (1fed ≒ 0.42ha)	MPa	: mega pascal
ft	: feet	m	: meter
g	: gram	MCM	: million cubic meter
ha	: hectare	min	: minute
hr	: hour	mm	: millimeter
kg	: kilogram	N	: newton
km	: kilometer	%	: percentile
kN	: kilo newton	s	: second
kV	: kilo volt	t	: ton
kVA	: kilo volt ampere		

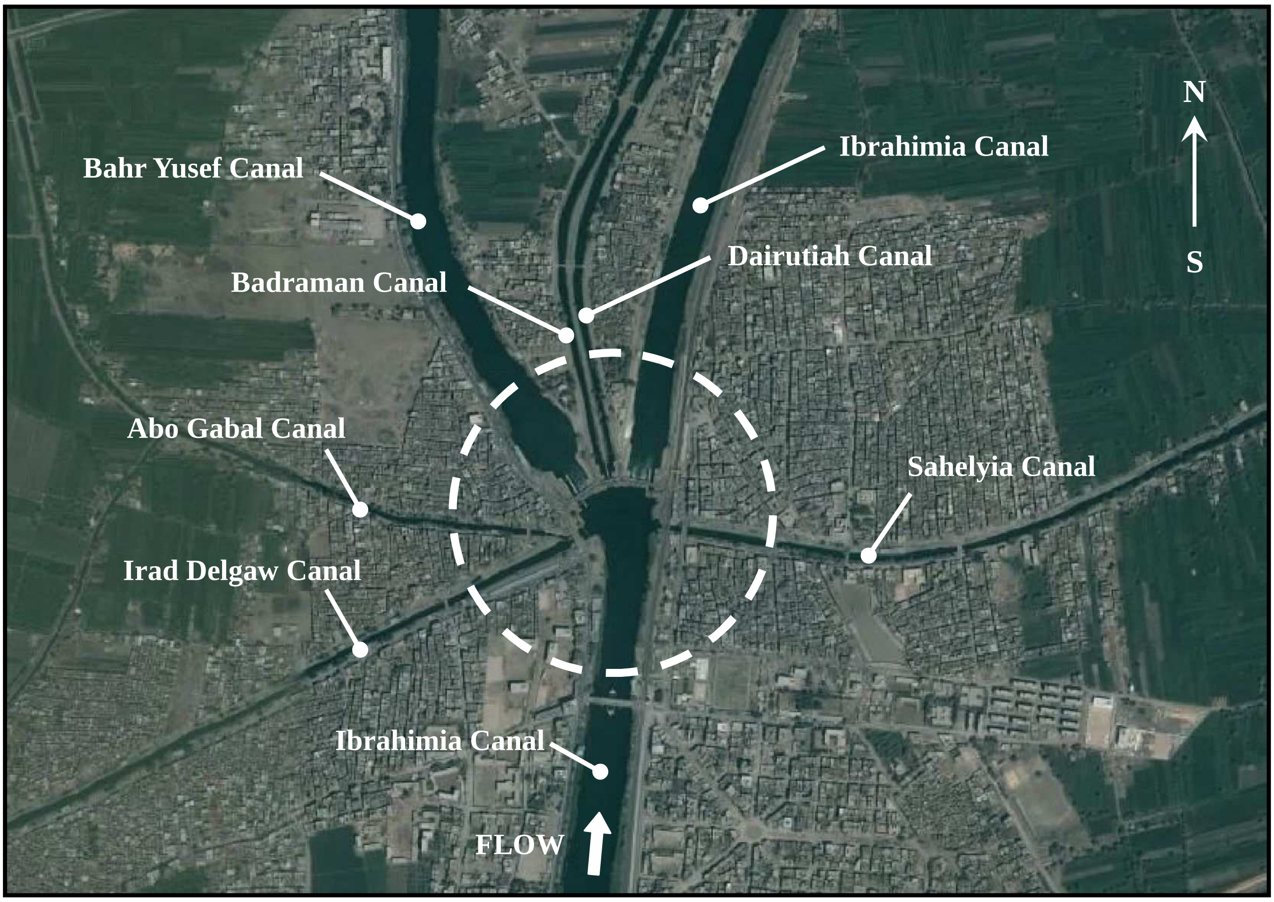
Currency		Exchange Rate (average from Feb. 2017 to Apr. 2017)
Egyptian Pound	(EGP or LE)	: 6.49 JPY/LE
Japanese Yen	(JPY)	
US Dollar	(USD)	: 113.34 JPY/USD
Euro	(EUR)	: 121.26 JPY/EUR

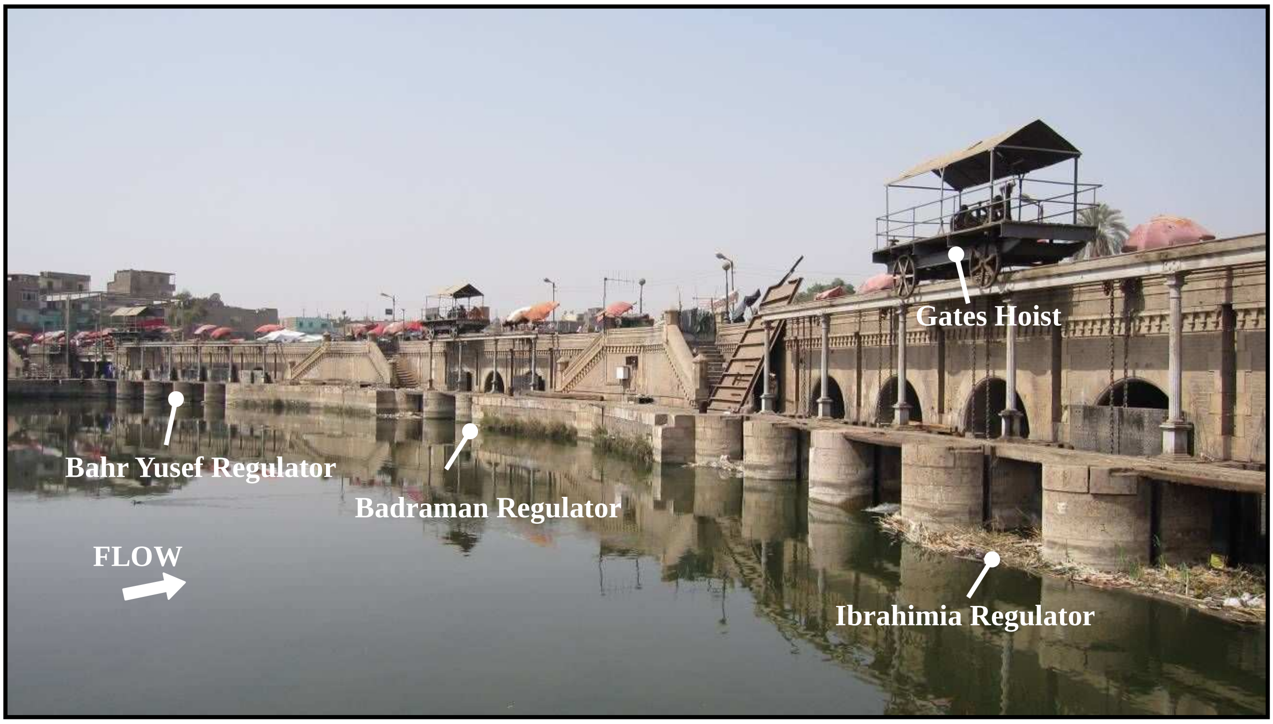
PROJECT LOCATION MAP

- PROJECT FOR CONSTRUCTION OF DIROUT GROUP OF REGULATORS -



PANORAMIC LANDSCAPE OF DIROUT GROUP OF REGULATORS





Project Photo

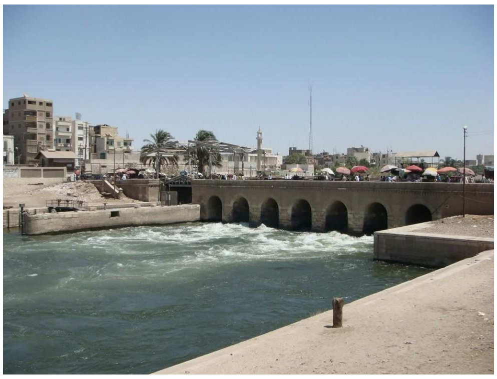


Photo1 ： Existing DGRs (Ibrahimia Regulator)
view from downstream

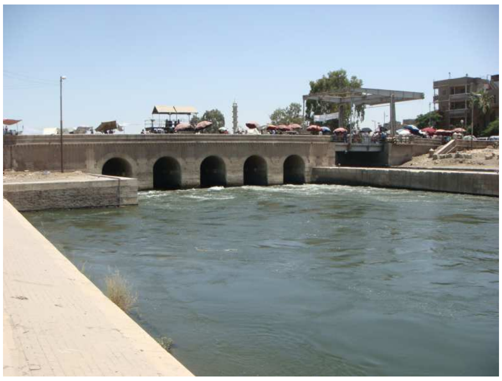


Photo2 ： Existing DGRs (Bahr Yusef Regulator)
view from downstream

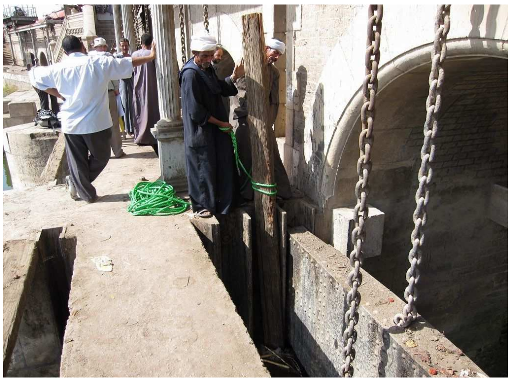


Photo3 : Current Gate Operation (with a log to push the gate)

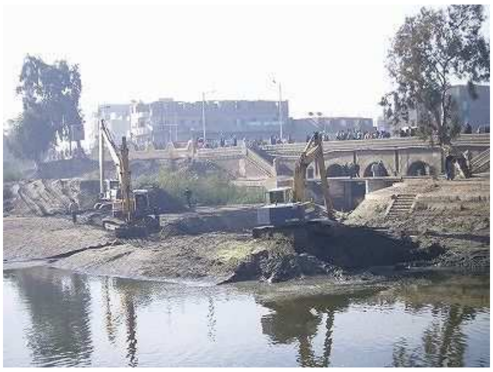


Photo4 ： Dredging (upstream of DGRs)

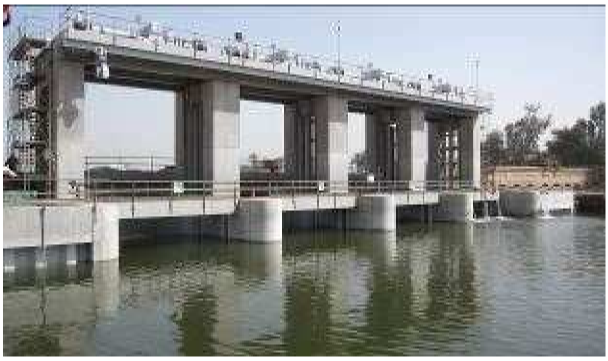


Photo5 : Distant view of Double leaf gates (Dahab Regulator)

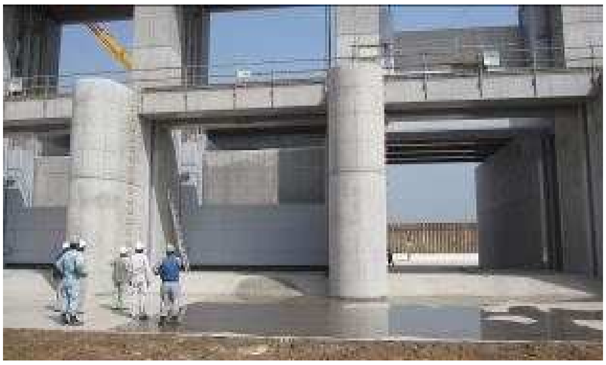


Photo6 ： Near view of Double leaf gates (Dahab Regulator)

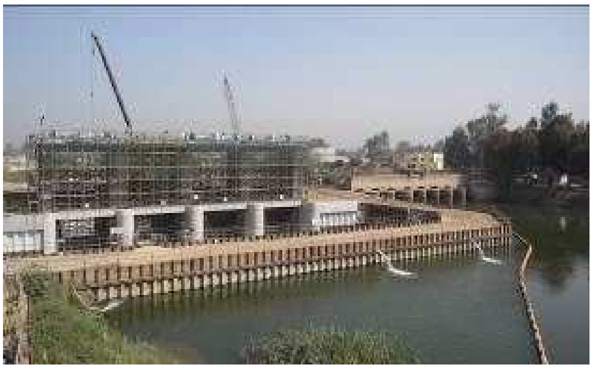
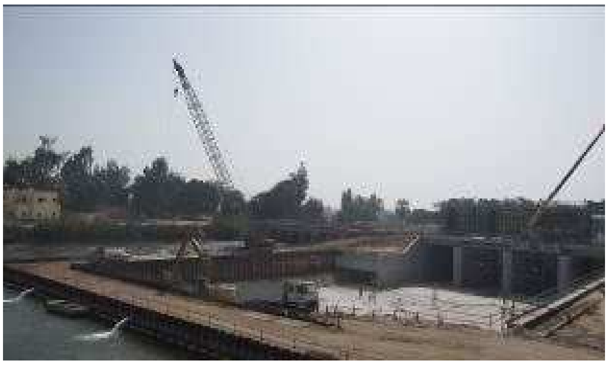


Photo7 ： Steel double sheet pile method (Dahab Regulator)



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Volume I – DESIGN OF REGULATORS

1. Outline of Design

1-1 Design conditions

(1) Design discharge for each regulator

Maximum design discharge for NDGRs was decided at the 6th TAC meeting. Maximum design discharge at this stage should take into account not only previous discharge which was applied in the F/S stage, but also the future demand on irrigation water. Discharge of Ibrahimia regulator in NDGRs, is accordingly upgraded to 186m^3/s from 161.6m^3/s. All design discharges are shown on Table 1-1.1. Design discharges of diversion works provided by the Egyptian side were applied to the diversion works in the construction stage.

Table 1-1.1 Design discharge

NDGR	Canal	Design Max. Discharge Qmax (m^3/s)	Design Min. Discharge Qmin (m^3/s)	Design Discharge for temporary works Qtem (m^3/s)	Note
Ibrahimia Reg.	Ibrahimia	186	23.6	162	
Bahr Yusef Reg.	Bahr Yusef	227	33.1	185	
Badraman Reg.	Badraman	9	1.2	6	
	Diroutiah	12	1.7	10	
Abo Gabal Reg.	Abo Gabal	7	0.9	2	
	Irad Delgaw	9	1.3	6	
Sahelyia Reg.	Sahelyia	5	0.6	3.5	

(2) Design water level

"Unusual" and "normal" water levels should be taken into account in the design water level on the NDGRs as stipulated at the 6th TAC meeting as follows.

According to the 1962 drawings of the existing rehabilitation plan, a high water level (H.W.L) of 47.00m was shown at the upstream. As this water level was designed before the construction of the Aswan High Dam, Nile and canal waters were not controlled by the dam. Today, water levels are controlled and floods do not occur under normal conditions. However, the inoperative Ibrahimia intake at the upstream which causes over-inflow to the NDGRs, requires the evaluation of the design water level in emergency situations. Accordingly, WL 47.00mas design at High High Water Level (H.H.W.L) should be applied for the emergency case, and in addition, WL 46.30m as design at HWL should be applied.

CDWD of MWRI provided the conditions of the downstream water level, and design should comply with these water levels. In addition, since each cross section of the existing canals does not have the necessary flow capacity, the upgrading works should be conducted as a different project to achieve the provided water levels. Reference 1-1.1 shows the H-Q curve at an existing cross section of Bahr Yusef and Ibrahimia canals. Table 1-1.2 shows the full design water level of each canal.

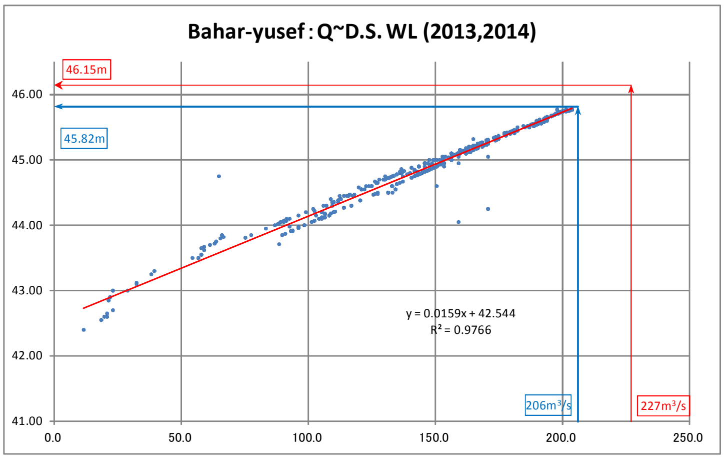
Table 1-1.2 Design water levels

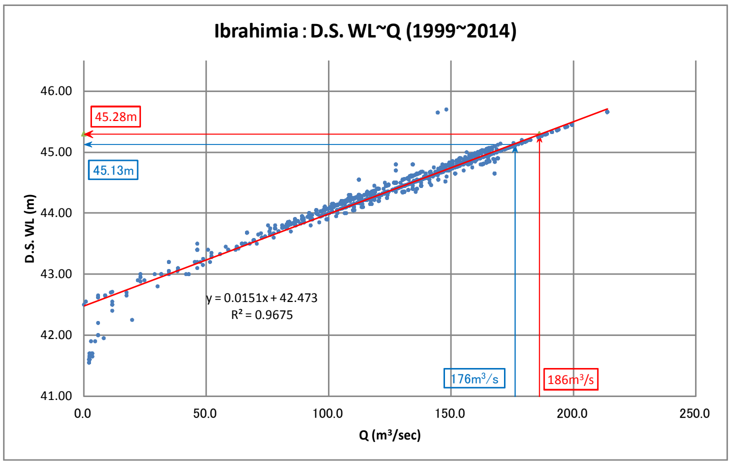
Regulator name	Canal name	US.HHWL (m)	US.HWL (m)	US.LWL (m)	US.LLWL (m)	DS.HWL (m)
Ibrahimia Reg.	Ibrahimia	47.00	46.30	45.90	—	45.13
Bahr Yusef Reg.	Bahr Yusef	47.00	46.30	45.90	—	45.82
Badraman Reg.	Badraman	47.00	46.30	45.90	—	45.90
	Diroutiah	47.00	46.30	45.90	—	45.90
Abo Gabal Reg.	Abo Gabal	47.00	46.30	45.90	44.30	45.90
	Irad Delgaw	47.00	46.30	45.90	44.30	45.90
Sahelyia Reg.	Sahelyia	47.00	46.30	45.90	44.30	45.90

Note 1: Upstream water level shows at upstream of the existing DGRs

Note 2: US. LLWL is taken from the actual records for the past five years as the available water level at Abo Gabal and Sahelyia regulators after the winter closure. Refer to reference Figure 1-1.2.

※Reference 1-1.1：H-Q curve at Bahr Yusef and Ibrahimia canal

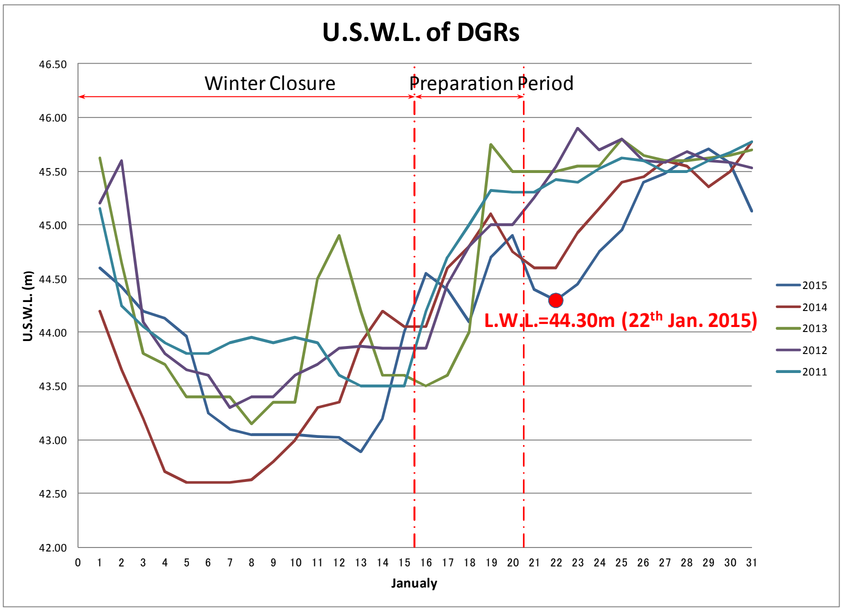




※Reference 1-1.2：Consideration of unusual upstream water level (US.LLWL)

The lowest upstream water level (US.LLWL) should be chosen from the five years record of just after the preparation period from 2011 to 2015 (see the graph below). As the result of the evaluation, US.LLWL should be determined as follows:

US.LLWL=44.30m (22th Jan 2015)



(3) Design of related facilities

Although no decision regarding the navigation lock and mini hydro power facilities was made at the F/S stage, after discussions between related Ministries, the Egyptian side decided that these facilities were unnecessary for the project.

a) Navigation lock

Neither navigation lock has been operated in the existing Bahr Yusef and Ibrahimia regulators in DGRs so far. Discussions at F/S stage deemed a navigation lock for the new Bahr Yusef regulator to be unnecessary, but encouraged the planning of the new Ibrahimia regulator.

At the 7th TAC meeting, discussions between MWRI and RTA concluded that no navigation locks need to be planned for the new Ibrahimia and the new Bahr Yusef regulators.

b) Mini hydro power generation

Mini hydro power generation was unable to generate the necessary electric power, due to the negative water level difference in F/S stage, and as such, the Egyptian side decided that that mini hydro power generation was unnecessary for the project. In this study, that conclusion was reviewed and agreed in the 6th TAC meeting. MWRI submitted an official letter stating that mini hydro power generators are infeasible and would not be constructed in NDGRs to MERE, the authority in charge of hydro power generation in Egypt.

1-2 Reference code

In the Arab Republic of Egypt (hereinafter referred to as Egypt), all irrigation facilities constructed based on the project plan and detailed design under MWRI management are required to follow the Egyptian code.

The Egyptian code is the design criteria for water resources development and irrigation works, and is accountable to NWRC. The contents of the parts of the Egyptian code relevant to the project are shown below.

Table 1-2.1 Contents of Egyptian code

Egyptian Code	Chapter
Operation of the Irrigation and Drainage Network part 1	1. Irrigation of the Agricultural Land
	2. Drainage of the Agricultural Land
Operation of the Irrigation and Drainage Network part 2	3. Horizontal expansion
	4. Water Resources Development
	5. Maintenance Work
	6. Hydrology Torrents Management
	7. Survey Works
Civilian Facilities on Irrigation and Drainage part 1	1. Irrigation Networks Lining
	2. Water Installations Intersecting
	3. Outfalls
	4. Weirs
	5. Regulators (Barrage) and Gates
	6. Dams
	7. Sluice gates Navigation
	8. Hydroelectric Power Plants
Civilian Facilities on Irrigation and Drainage part 2	9. Pump Stations
	10. Wells
	11. Bridges
	12. Tunnels
Irrigation and Drainage Mechanical works	1. Pumps
	2. Internal Combustion Engines
	3. Transmission and Power rate
	4. Valves and Gates
	5. Mechanical, Chemical and Cathodic Protections
	6. Selection and Testing of Materials
	7. Mechanical Equipment for Maintenance of Water Ways
	8. Advance for Irrigation Equipment
	9. Monitoring Water Quality in Streams Equipment
Irrigation and Drainage Electrical works	1. Electric Stations
	2. Electric Transformers and Accessories
	3. Keys, Electrical Connection and Electrical Fittings
	4. Circles and Control Devices in Electric Motors
Irrigation and Drainage Electrical works	5. Terms Implementation of Electric Works
	6. Power Supply Emergency Systems

Egyptian Code	Chapter
	7. Grounding
	8. Irrigation Equipment Powered by Electricity
Shore Protection Techniques	1. Natural Factor Affecting the Costal and Beach Areas
	2. Research Studies, Field work, Hydraulic Models and
	3. Facilities, Shore Protection Plan and its Impact on the
	4. Designer Protection
	5. Shore Protection and Maintenance Facilities

Adherence to the Egyptian code was given first priority in the design criteria applied at the basic design and the detailed design stages for NDGRs construction project. In the absence of a policy in the Egyptian code regarding an issue, Japanese design criteria in the field of the regulators and *Design Criteria for Irrigation and Drainage, Headworks* will be referred to.

The design criteria adopted for the study, is defined in chapter five "*Regulators (Barrage) and Gates in the Civilian Facilities on Irrigation and Drainage.*" Part one of the chapter consists of following items:

5-1 Definition
5-2 Gate Types
5-3 Mutual affect between the Hydraulic Structure and Water Channel
5-4 Regulator Design
5-5 Gates
5-6 References

In the Japanese Criteria, the methodology for the design of the headworks is defined with great attention to theory and method. In the Egyptian code, the maximum velocity allowed at the vents is defined as follows with limited expansion and details.

Small scale regulators	1 - 1.5 m/sec
Large scale regulators (barrage)	1.5 - 2 m/sec
Barrage on Rivers	2.5 – 3.5 m/sec

To fill the gaps in the details left by the Egyptian code, the RGBS recommended the textbook *Part No. 2 Design of Hydraulic Structures, Spillways, Regulators and Barrage*, for design works.

Adherence to the Egyptian code was given first priority in defining the hydraulic dimensions at the Basic Study stage, the textbook only providing supplemental criteria.

1-3 Outline of facilities

Figure 1-3.1 and Table 1-3.1 show the outline of the NDGRs

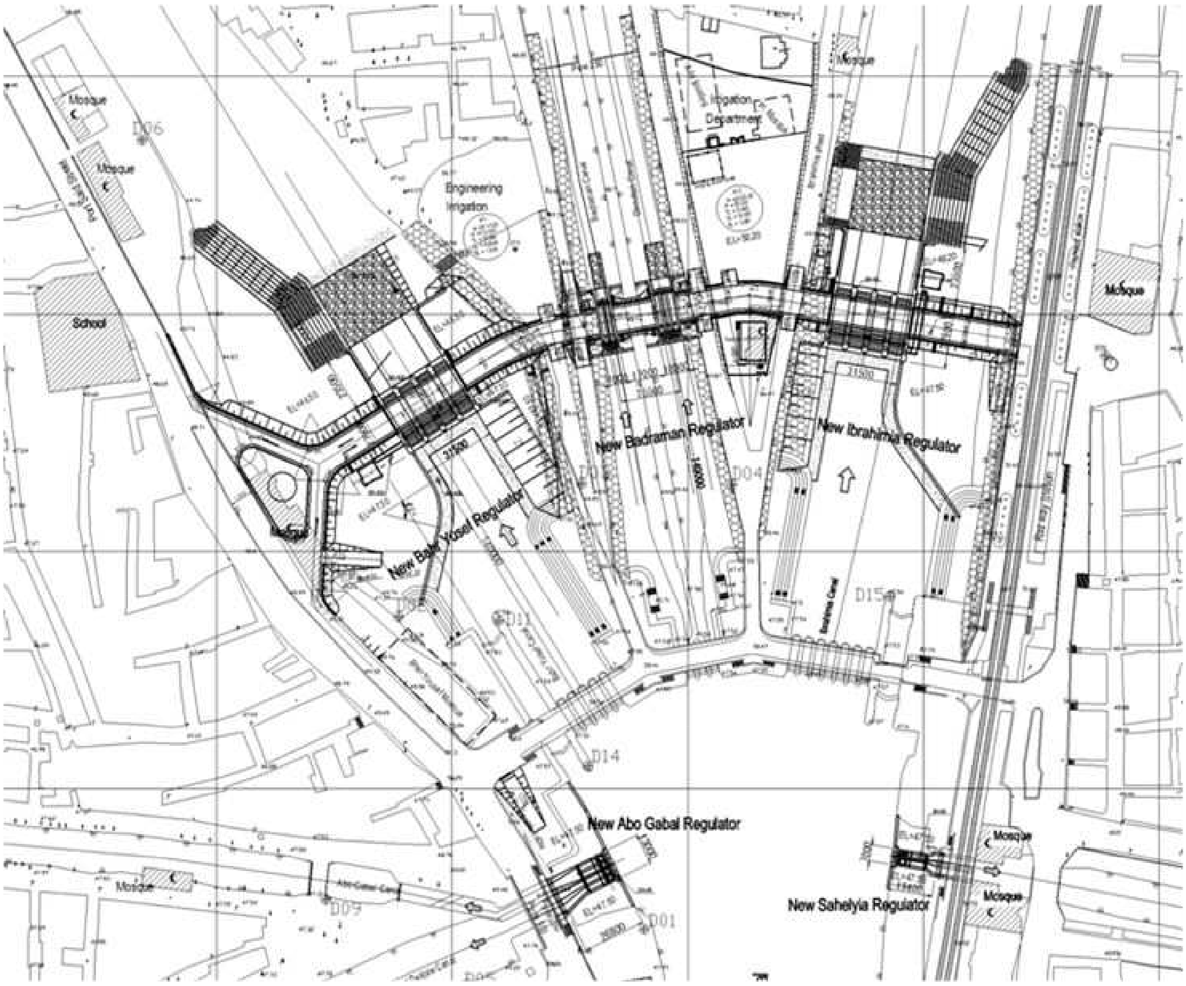


Figure 1-3.1 General layout of NDGRs

Table 1-3.1 Outline of NDGRs

Name of Regulator		Bahr Yusef	Ibrahimia	Badraman		AboGabal		Sahelyia	Remarks
Name of Canal				**Badraman**	**Diroutiah**	**AboGabal**	**Irad Delgaw**		
Design maximum discharge		227 m^3/s	186 m^3/s	9 m^3/s	12 m^3/s	7 m^3/s	9 m^3/s	5 m^3/s	Total 455m^3/s
Design minimum discharge		33.1 m^3/s	23.6 m^3/s	1.2 m^3/s	1.7 m^3/s	0.9 m^3/s	1.3 m^3/s	0.6 m^3/s	Total 60.7m^3/s
Design U/S high water level		EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	
Design U/S low water level		EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	
Design D/S high water level		EL45.82m	EL45.13m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	
Width of vent		6.00m	6.00m	2.00m	2.00m	2.00m		2.00m	
Number of vent		4	4	2	3	4		2	
Gate sill elevation		EL40.00m	EL40.00m	EL43.90m	EL44.20m	EL43.60m		EL43.00m	
Gate crest elevation		EL46.55m	EL46.55m	EL46.55m	EL46.55m	EL46.55m		EL46.55m	
Total gate height		6.55m	6.55m	2.65m	2.35m	2.95m		3.55m	
Foundation	Main body	Cast-in-place RC pile	Cast-in-place RC pile	Raft foundation	Raft foundation	Raft foundation		Raft foundation	
	Apron	Raft foundation	Raft foundation	Raft foundation	Raft foundation	Raft foundation		Raft foundation	
	L-shape wall	Cast-in-place RC pile	Cast-in-place RC pile	-	-	-		-	
Downstream apron	Type	L-type retaining wall	L-type retaining wall	RC flume	RC flume	RC flume		RC flume	
	Length	44.25m	44.25m	23.35m	22.77m	23.87m		16.42m	Note(1)
Seepage control works		Steel sheet pile	Steel sheet pile	Steel sheet pile	Steel sheet pile	Steel sheet pile		Steel sheet pile	
Bed protection works		Riprap L=30.0m (D_{50}=0.40m,W_{50}=60kg,t=1.00m)	Riprap L=30.0m (D_{50}=0.40m,W_{50}=60kg,t=1.00m)	Riprap L=15.0m (D_{50}=0.20m,W_{50}=10kg,t=0.50m)	Riprap L=15.0m	–		–	t : Thickness including gravel (0.10m)
Bank protection works	D/S	Cantilevered type/Brace type steel sheet pile wall	Cantilevered type/Brace type steel sheet pile wall	Cantilevered sheet pile wall	Cantilevered sheet pile wall	–		–	
		Gabion wall	Gabion wall						
	U/S	Brace type steel sheet pile wall	Cantilevered type/Brace type steel sheet pile	Cantilevered sheet pile wall	Cantilevered sheet pile wall	Brace type steel sheet pile wall		Brace type steel sheet pile wall	
		Wet stone pitching	Wet stone pitching						
Bridge		RC, Total width=12.5m	RC, Total width=12.5m	RC,Total width=12.5m	RC,Total width=12.5m	RC,Total width=6.0m		RC,Total width=6.0m	
Gate facility	Type	Double leaf Fixed wheel gate	Double leaf Fixed wheel gate	Single leaf Slide gate	Single leaf Slide gate	Single leaf Slide gate		Single leaf Slide gate	
	Hoist	Hydraulic cylinder	Hydraulic cylinder	Electric motor	Electric motor	Electric motor		Electric motor	
	Operation speed	0.3 m/min	0.3 m/min	0.3 m/min	0.3 m/min	0.3 m/min		0.3 m/min	
	Material	Rolled steel & Stainless steel(Guide frame, bolt & nut, wheels)							
	Stoplogs	1 set	1 set	2 sets					Note(2)
		Height of one piece=1.35m&1.20m		Height of one piece=0.95m&0.85m					
Management facility		Remote control building: RC structure, 2 floors (Stoplogs storage house is established together)							Location and the area is under study
		Local control room: RC structure, 2 rooms (Bahr Yusef & Ibrahimia Regulator)							
Water level gauge		2 sets (U/S:1,D/S:1)	2 sets (U/S:1,D/S:1)	2 sets (U/S:1,D/S:1)	2 sets (U/S:1,D/S:1)	3 sets (U/S:1,D/S:2)		2 sets (U/S:1,D/S:1)	Pressure type

Note: (1) Length of downstream apron for small regulators shows the distance from a gate sill to the existing structure.
(2) One set means a pair of stoplogs for upstream and downstream.
U/S:Upstream, D/S:Downstream

2. Topographic and Geological Outline

2-1 Topographic feature

The flood plain of the Nile has been formed by Nile sedimentation onto the eroded limestone plateau which was aggraded in early Eocene time. The flood plain is mainly composed of silt and sand, and is suitable for agriculture due to its fertility. According to an old map of the area (*Carte topographique de l'Égypte et de plusieurs parties des pays limitrophes*, 1826), Dirout El-Shareef city, which is 2.7km north of Dirout city, was situated along the original Bahr Yusef river (Figure 2-1.1 and Figure 2-1.2). This indicates that much excavation and reclamation work has been implemented around the target area in order to divert the water from the Ibrahimia canal into the Bahr Yusef river as Bahr Yusef canal.

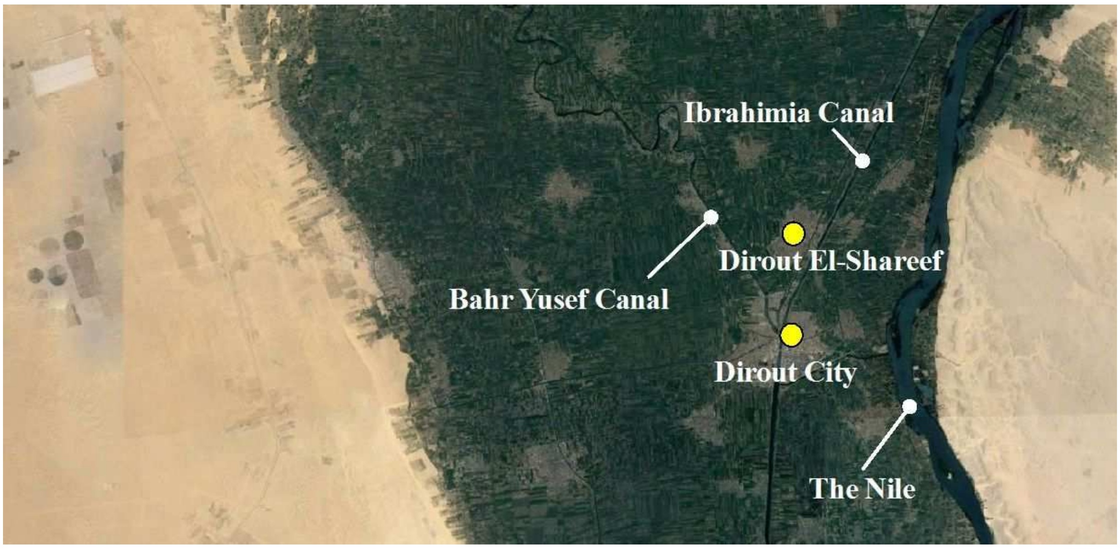


Figure 2-1.1 Satellite picture (Dirout to Malawi)

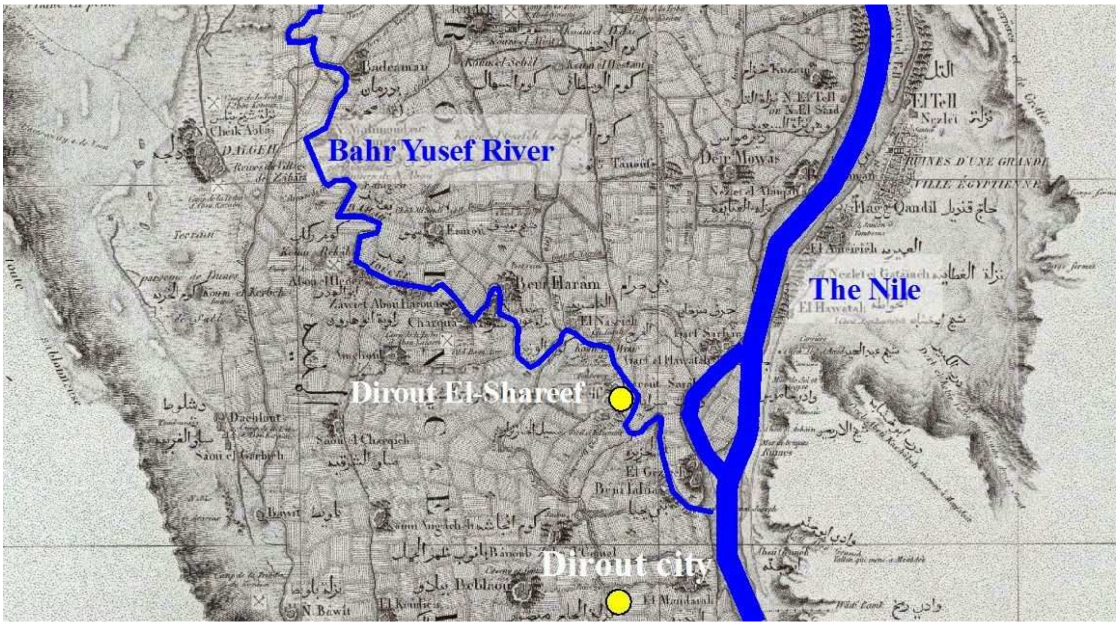


Figure2-1.2 Antique map (1826, Dirout to Malawi)

（Source: *Carte topographique de l'Égypte et de plusieurs parties des pays limitrophes*, 1826）

2-2 Geological feature

Geological structures around Dirout city feature an erosion valley striding over 15km to 20km beyond the river terrace developed over different geological times. Diluvium formation which formed the river terrace is consequently seen under the river Nile, but alluvium sediments is covered in the study area which is beside the current river Nile. The condition of Nile deposits depends on changes in hydraulic gradient caused by eustasy, and changes in the river course caused by tectonism (shown on Figure 2-2.1).

The geological field survey of the study area corresponds to the Neonile or Prenile description (Said 1993). Table 2-2.1 shows the features for those units.

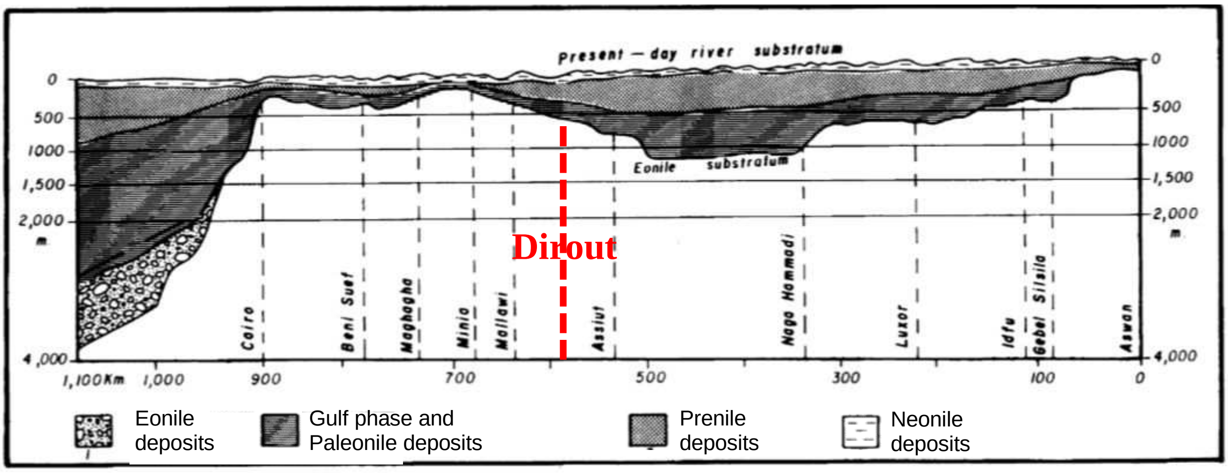


Figure 2-2.1 Geological profile of the Nile（Aswan to Mediterranean sea）

(Source: Rushdi Said *The River Nile*, 1993)

Table 2-2.1 Description of flood sediments

Unit	Remarks (Stratigraphication and distribution)
Neonile	This river system is the current condition of the Nile (0.4Ma-present), and is categorized into 4 types of deposits, α, β, γ, and δ-Neonile considering the regression/transgression cycle. They are mainly composed of riverine (flood) deposits (silt and sand, and occasional gravel) and inter-fingered dune sand.
Prenile	It is mainly composed of two types of sand layers, one for cross-bedding riverine sand, and another for inter-bedding dune sand in the middle Pleistocene (0.8 – 0.4Ma). The deposit from this river system includes mollusca and fauna which indicate that this river system is connected to Ethiopia (Said 1990). This river system conveyed massive amounts of sand on the Nile valley which resulted in considerably thick sand layer even in Upper Egypt.

2-3 Borehole logs

The location of borehole and borehole logs which relate the foundation properties for B/D stage are shown in the following figures. (See the *Field Survey Report* (April 2016) of the D/D study in regard with the detail information for the past boring surveys).

a) Location of the survey

The boring survey was carried out at fifteen borehole points in order to clarify the change in stratigraphy on the new axis, and the soil properties were determined through in-situ and laboratory tests. The results support the design of main regulators, navigation locks, piers, sheet piles, and all related structures in the construction of NDGRs. A location map for the boreholes is shown in Figure 2-3.1.

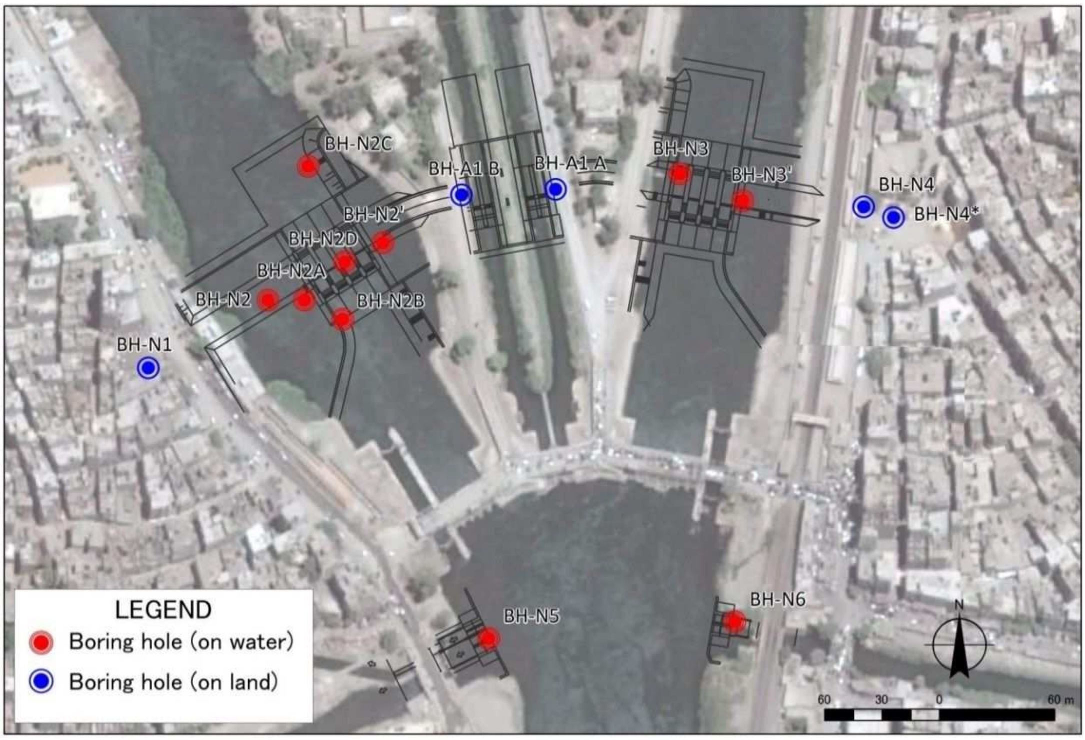


Figure 2-3.1 Location map of boreholes on NDGRs

b) Borehole logs

Figures 2-3.2 to 2-3.5 show the geological cross-sectional maps of the regulators and SPT values. Figures 2-3.6 to 2-3.19 show all 15 borehole logs on the new Bahr Yusef, Badraman, Diroutiah, and Ibrahimia regulators.

According to the borehole logs obtained in the survey, thick silt layer is overlain at the depth of 10m, changing from silt to sand with depth. Coarse facies intercalated with granule and pebble are dominant at the bottom of the boreholes. This upper silt may be correlated to γ-Neo-Nile (or δ-Neo-Nile) sub-stage, and the lower part of the sandy layer succession can be compared with a part of γ-Neo-Nile sequence[1] (or δ-Neo-Nile). It should be remarked that a loose backfill layer (containing mainly unconsolidated silt to clay, and traces of brick particles) exists under the new Bahr Yusef regulator. That backfill layer is classified into two layers, top and bottom, with an interbedded silt layer with a trace of shell fragments.

---

[1] Sediment sequence: A succession of geologic events, processes, or layers, arranged in chronologic order to show their relative position and age with respect to geologic history as a whole. In the Dirout area in particular, sediment layer(s) indicate a transgressive deposit, consisting of low lying gravel overlain by a finer layer of sand/silt on the surface. This is influenced by past sedimentation in response to a seawater rise after the middle Pleistocene time.

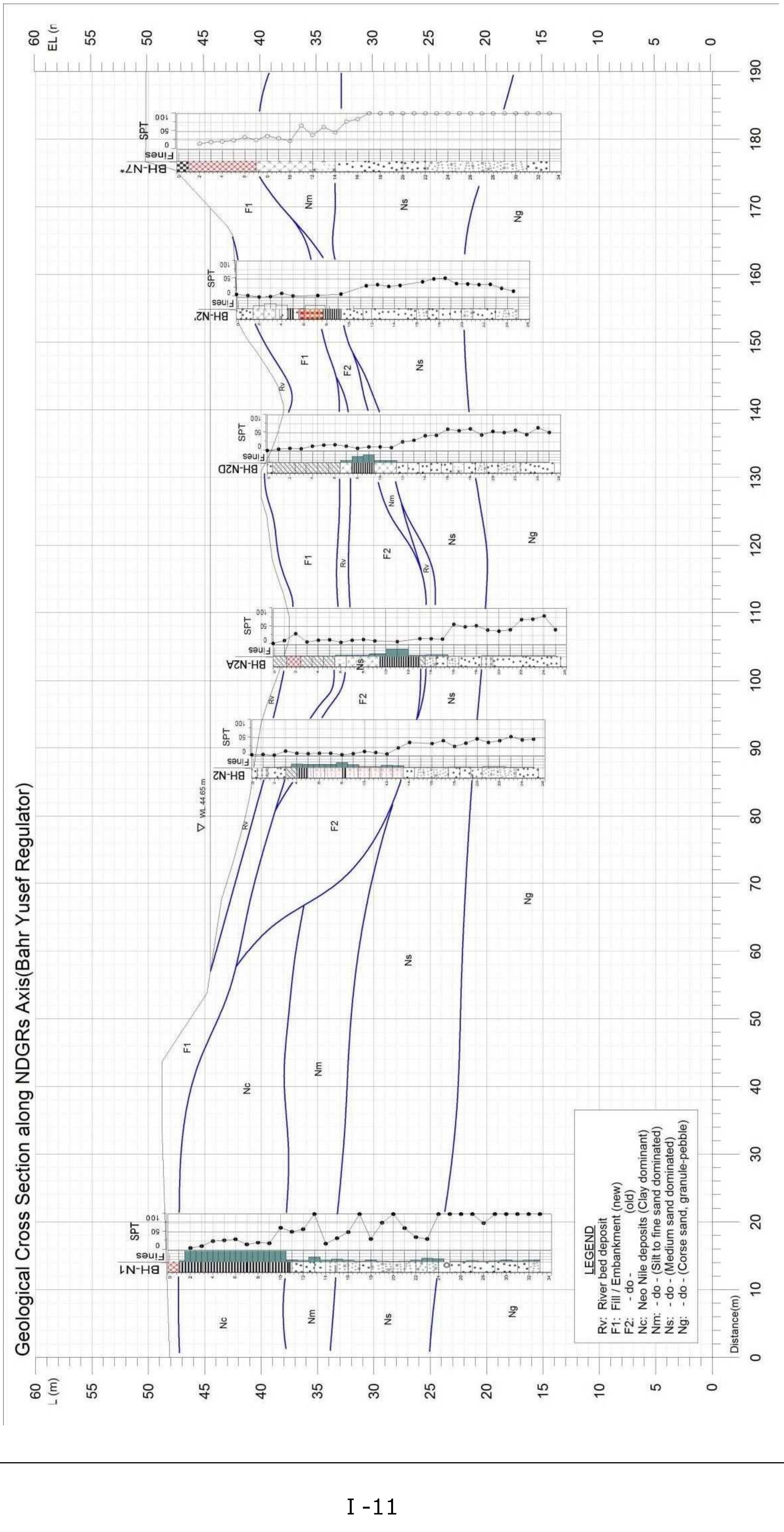

Geological Cross Section along NDGRs Axis(Bahr Yusef Regulator)
EL (m)
Distance(m)
BH-N1
BH-N2
BH-N2A
BH-N2D
BH-N2'
BH-N7*
Fines
SPT
WL 44.65 m
Rv
F1
F2
Nc
Nm
Ns
Ng
LEGEND
Rv: River bed deposit
F1: Fill / Embankment (new)
F2: - do - (old)
Nc: Neo Nile deposits (Clay dominant)
Nm: - do - (Silt to fine sand dominated)
Ns: - do - (Medium sand dominated)
Ng: - do - (Corse sand, granule-pebble)

Figure 2-3.2 Geological cross-sectional map (New Bahr Yusef regulator)

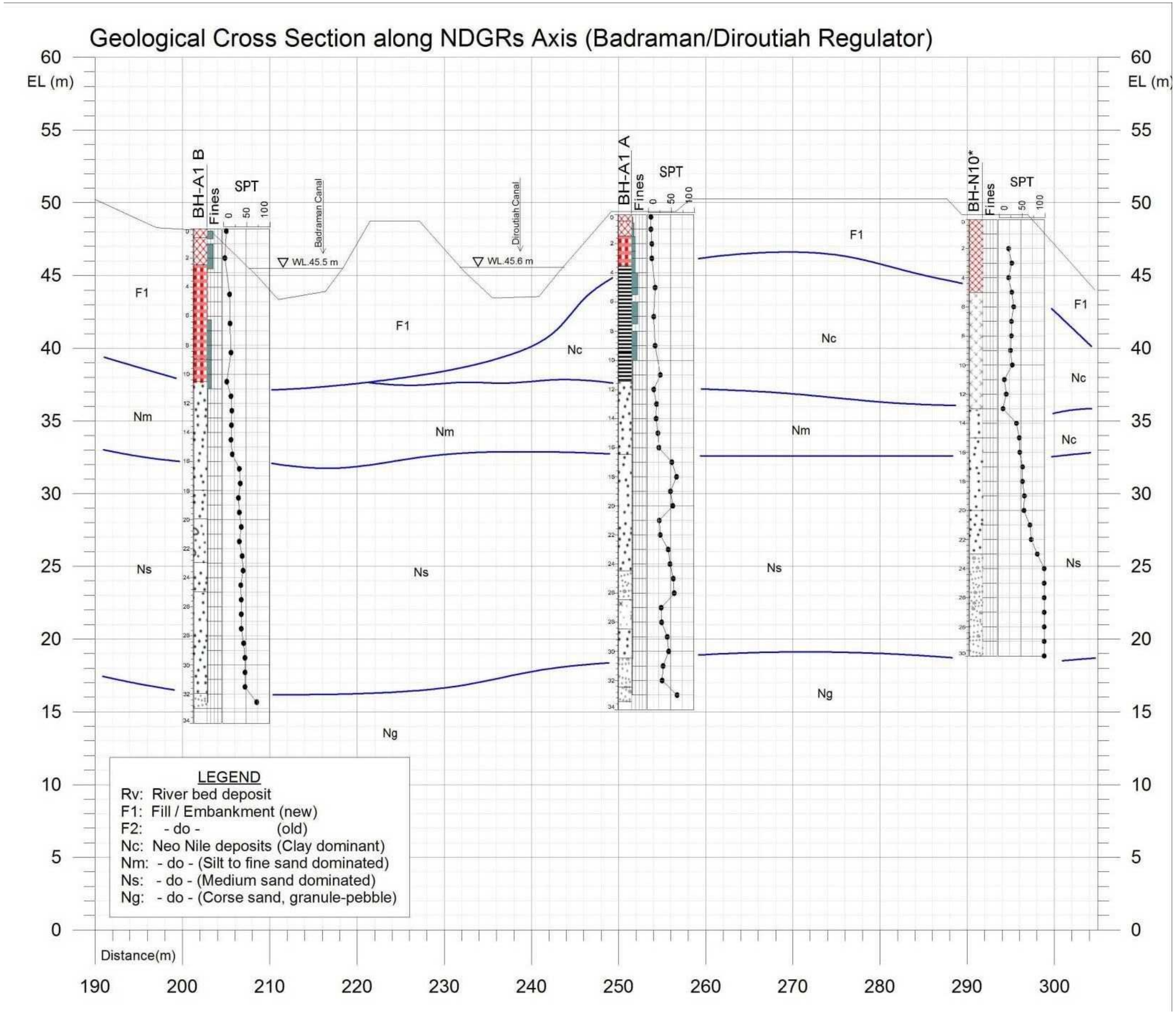

Geological Cross Section along NDGRs Axis (Badraman/Diroutiah Regulator)
EL (m)
60
55
50
45
40
35
30
25
20
15
10
5
0
Distance(m)
190
200
210
220
230
240
250
260
270
280
290
300
BH-A1 B
BH-A1 A
BH-N10*
Fines
SPT
0
50
100
Badraman Canal
WL.45.5 m
Diroutiah Canal
WL.45.6 m
F1
Nc
Nm
Ns
Ng
LEGEND
Rv: River bed deposit
F1: Fill / Embankment (new)
F2: - do - (old)
Nc: Neo Nile deposits (Clay dominant)
Nm: - do - (Silt to fine sand dominated)
Ns: - do - (Medium sand dominated)
Ng: - do - (Corse sand, granule-pebble)

Figure 2-3.3 Geological cross-sectional map (New Badraman to Diroutiah regulators)

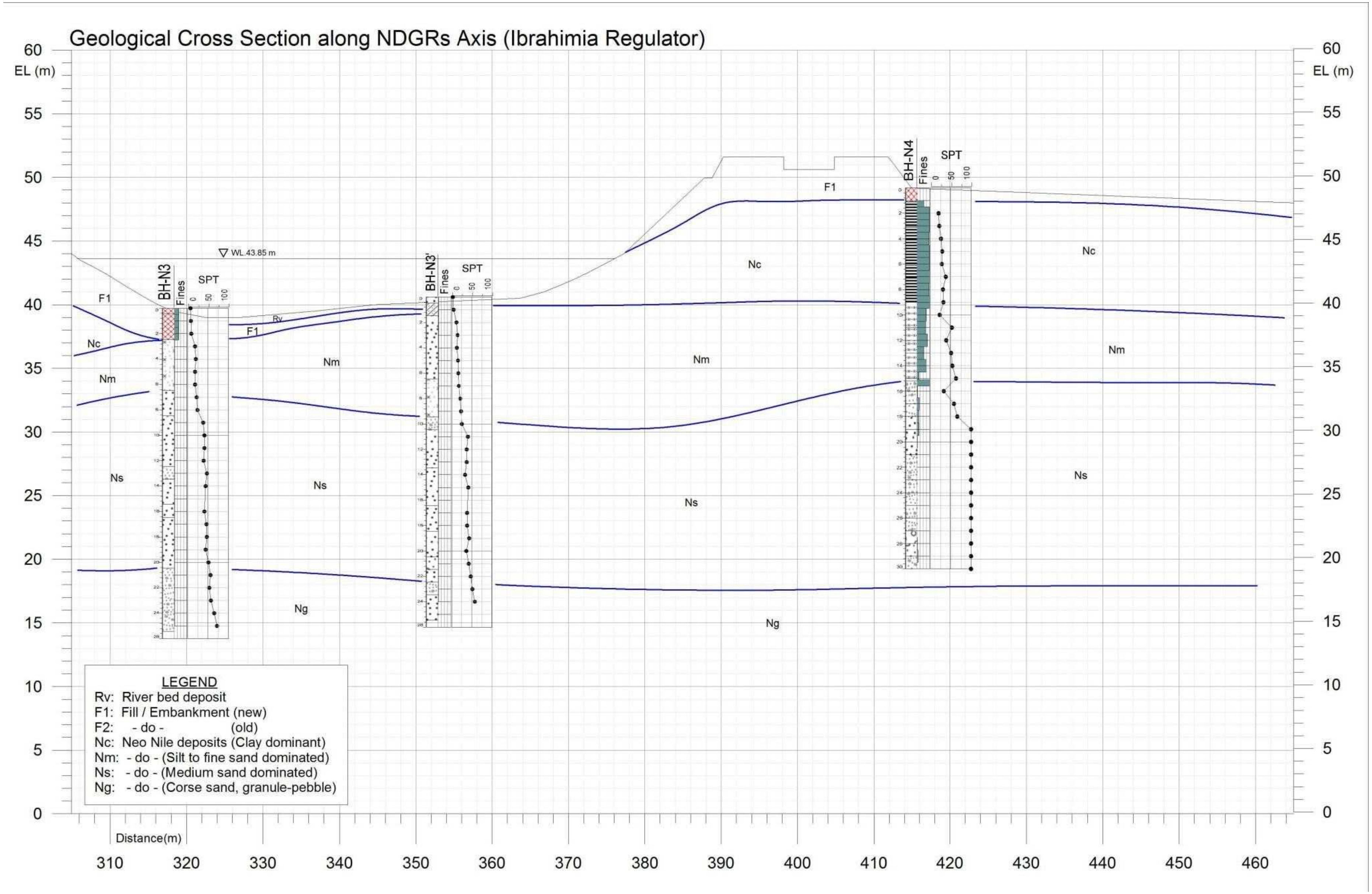
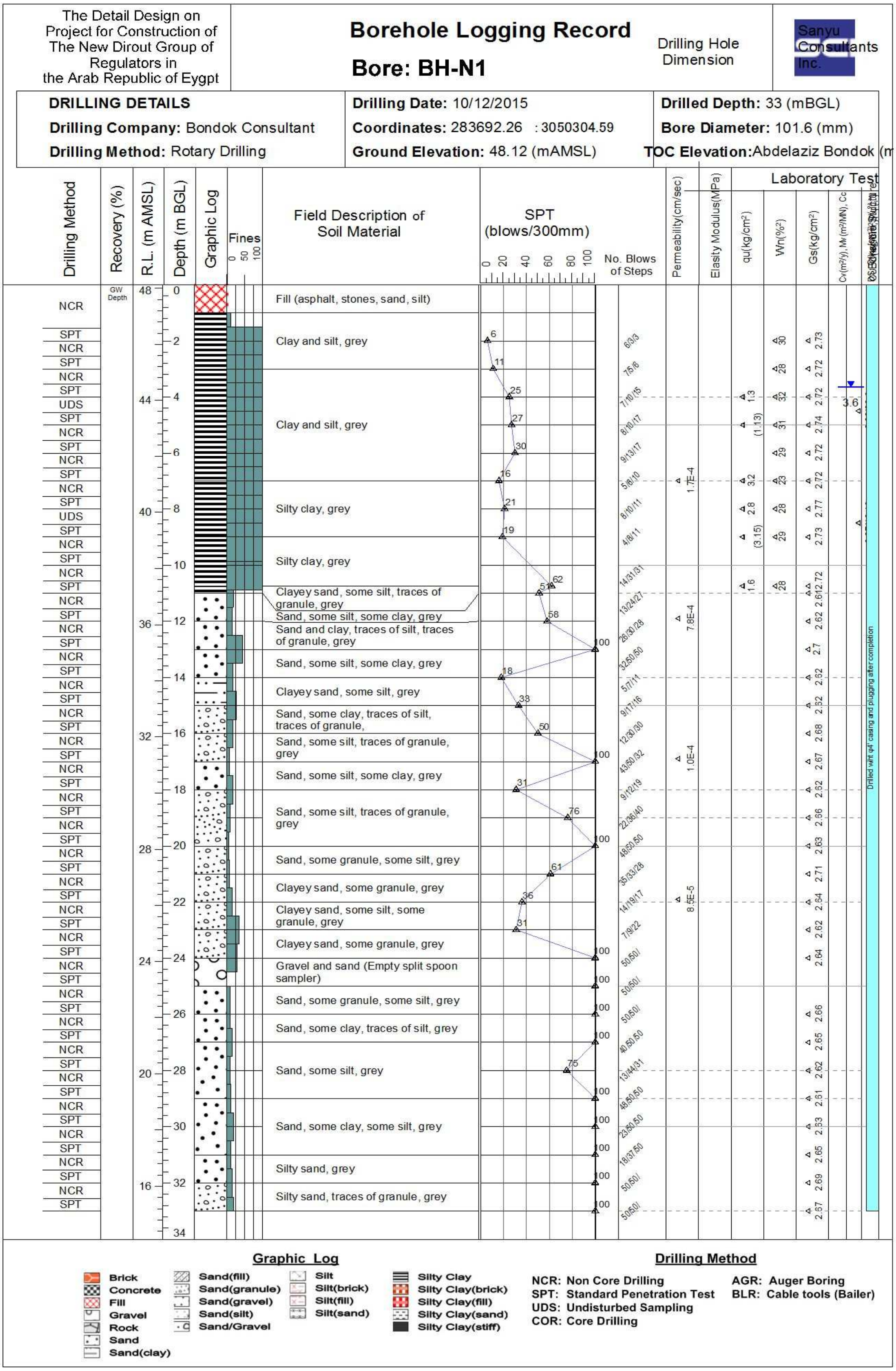

Geological Cross Section along NDGRs Axis (Ibrahimia Regulator)
EL (m)
60
55
50
45
40
35
30
25
20
15
10
5
0
Distance(m)
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450
460
WL 43.85 m
BH-N3
BH-N3'
BH-N4
Fines
SPT
0
50
100
F1
Rv
Nc
Nm
Ns
Ng
LEGEND
Rv: River bed deposit
F1: Fill / Embankment (new)
F2: - do - (old)
Nc: Neo Nile deposits (Clay dominant)
Nm: - do - (Silt to fine sand dominated)
Ns: - do - (Medium sand dominated)
Ng: - do - (Corse sand, granule-pebble)

Figure 2-3.4 Geological cross-sectional map (New Ibrahimia regulator)



The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N1

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Bondok Consultant

Drilling Method: Rotary Drilling

Drilling Date: 10/12/2015

Coordinates: 283692.26 : 3050304.59

Ground Elevation: 48.12 (mAMSL)

Drilled Depth: 33 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation: Abdelaziz Bondok (m

Field Description of Soil Material
Fill (asphalt, stones, sand, silt)
Clay and silt, grey
Clay and silt, grey
Silty clay, grey
Silty clay, grey
Clayey sand, some silt, traces of granule, grey
Sand, some silt, some clay, grey
Sand and clay, traces of silt, traces of granule, grey
Sand, some silt, some clay, grey
Clayey sand, some silt, grey
Sand, some clay, traces of silt, traces of granule,
Sand, some silt, traces of granule, grey
Sand, some silt, some clay, grey
Sand, some silt, traces of granule, grey
Sand, some granule, some silt, grey
Clayey sand, some granule, grey
Clayey sand, some silt, some granule, grey
Clayey sand, some granule, grey
Gravel and sand (Empty split spoon sampler)
Sand, some granule, some silt, grey
Sand, some clay, traces of silt, grey
Sand, some silt, grey
Sand, some clay, some silt, grey
Silty sand, grey
Silty sand, traces of granule, grey

No. Blows of Steps	SPT (blows/300mm)
6/3/3	6
7/5/6	11
7/10/15	25
8/10/17	27
9/13/17	30
5/6/10	16
8/10/11	21
4/8/11	19
14/31/31	62
13/24/27	51
26/30/28	58
32/50/50	100
5/7/11	18
9/17/16	33
12/30/30	50
43/50/32	100
9/12/19	31
22/36/40	76
48/50/50	100
35/33/28	61
14/19/17	36
7/9/22	31
50/50/	100
50/50/	100
50/50/	100
40/50/50	100
13/44/31	75
48/50/50	100
23/50/50	100
18/37/50	100
50/50/	100
50/50/	100

Drilling Method: NCR, SPT, NCR, SPT, NCR, SPT, UDS, SPT, NCR, SPT, NCR, SPT, NCR, SPT, UDS, SPT, NCR, SPT

GW Depth: 3.6

Permeability(cm/sec): 1.7E-4; 7.8E-4; 1.0E-4; 8.5E-5

qu(kg/cm²): 1.3; (1.13); 3.2; 2.8; (3.15); 1.6

Wn(%): 30; 28; 32; 31; 29; 23; 28; 29; 28

Gs(kg/cm²): 2.73; 2.72; 2.72; 2.74; 2.72; 2.72; 2.77; 2.73; 2.61; 2.72; 2.62; 2.7; 2.62; 2.32; 2.68; 2.67; 2.62; 2.66; 2.63; 2.71; 2.64; 2.62; 2.64; 2.66; 2.65; 2.62; 2.61; 2.53; 2.65; 2.69; 2.67

Drilled wiht φ4' casing and plugging after completion

Graphic Log

Brick	Sand(fill)	Silt	Silty Clay
Concrete	Sand(granule)	Silt(brick)	Silty Clay(brick)
Fill	Sand(gravel)	Silt(fill)	Silty Clay(fill)
Gravel	Sand(silt)	Silt(sand)	Silty Clay(sand)
Rock	Sand/Gravel		Silty Clay(stiff)
Sand			
Sand(clay)			

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.5 Borehole log (BH-N1)

The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

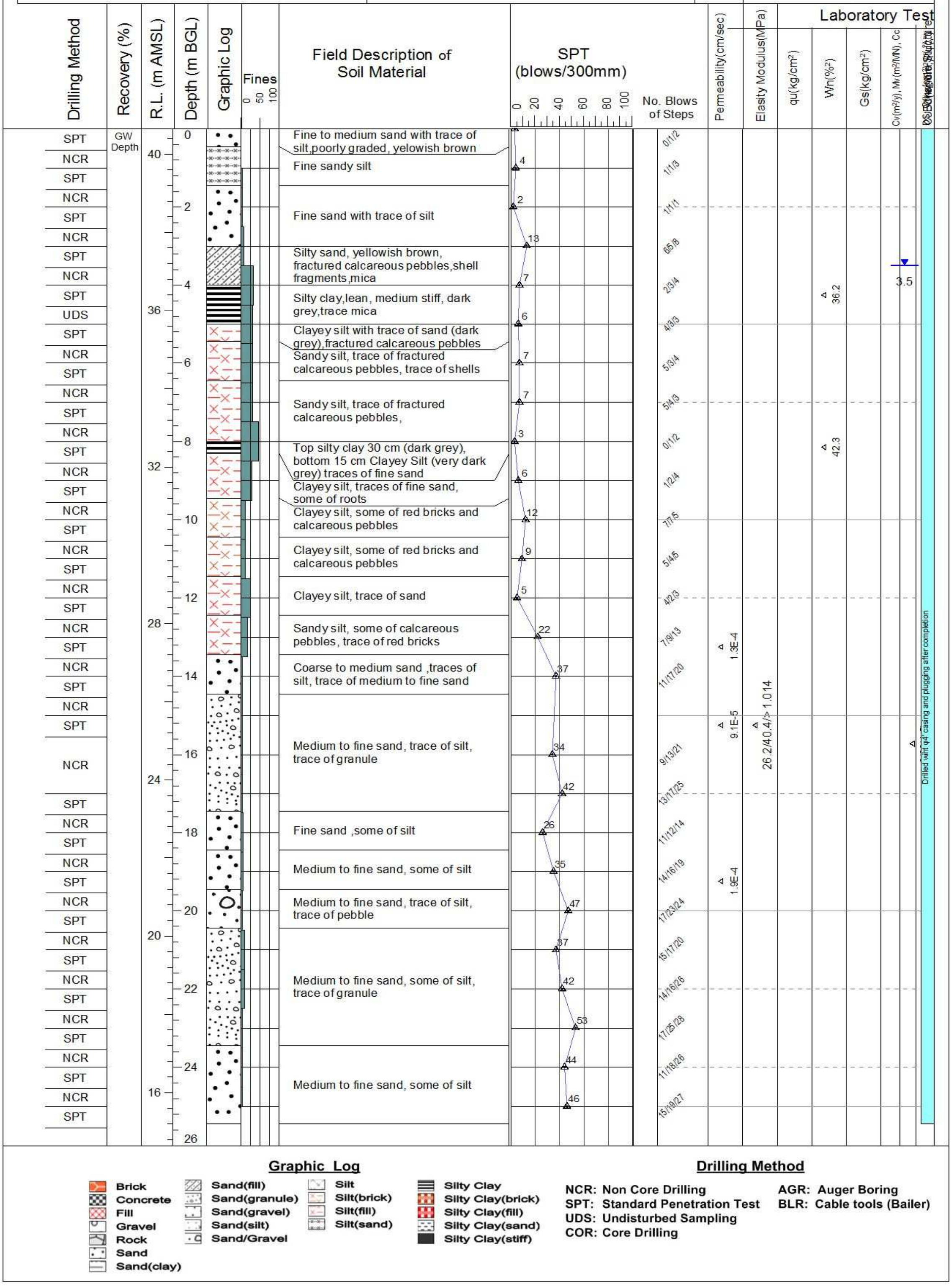
Borehole Logging Record

Bore: BH-N2

Drilling Hole
Dimension

Sanyu
Consultants
Inc.

DRILLING DETAILS	**Drilling Date:** 12/23/2015	**Drilled Depth:** 25.45 (mBGL)
Drilling Company: Misr Raymond F.	**Coordinates:** 283755 : 3050340	**Bore Diameter:** 101.6 (mm)
Drilling Method: Rotary Drilling	**Ground Elevation:** 40.65 (mAMSL)	**TOC Elevation:** M. Essam (mAGL)



Fine to medium sand with trace of silt,poorly graded, yelowish brown

Fine sandy silt

Fine sand with trace of silt

Silty sand, yellowish brown, fractured calcareous pebbles,shell fragments,mica

Silty clay,lean, medium stiff, dark grey,trace mica

Clayey silt with trace of sand (dark grey),fractured calcareous pebbles

Sandy silt, trace of fractured calcareous pebbles, trace of shells

Sandy silt, trace of fractured calcareous pebbles,

Top silty clay 30 cm (dark grey), bottom 15 cm Clayey Silt (very dark grey) traces of fine sand

Clayey silt, traces of fine sand, some of roots

Clayey silt, some of red bricks and calcareous pebbles

Clayey silt, some of red bricks and calcareous pebbles

Clayey silt, trace of sand

Sandy silt, some of calcareous pebbles, trace of red bricks

Coarse to medium sand ,traces of silt, trace of medium to fine sand

Medium to fine sand, trace of silt, trace of granule

Fine sand ,some of silt

Medium to fine sand, some of silt

Medium to fine sand, trace of silt, trace of pebble

Medium to fine sand, some of silt, trace of granule

Medium to fine sand, some of silt

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.6 Borehole log (BH-N2)

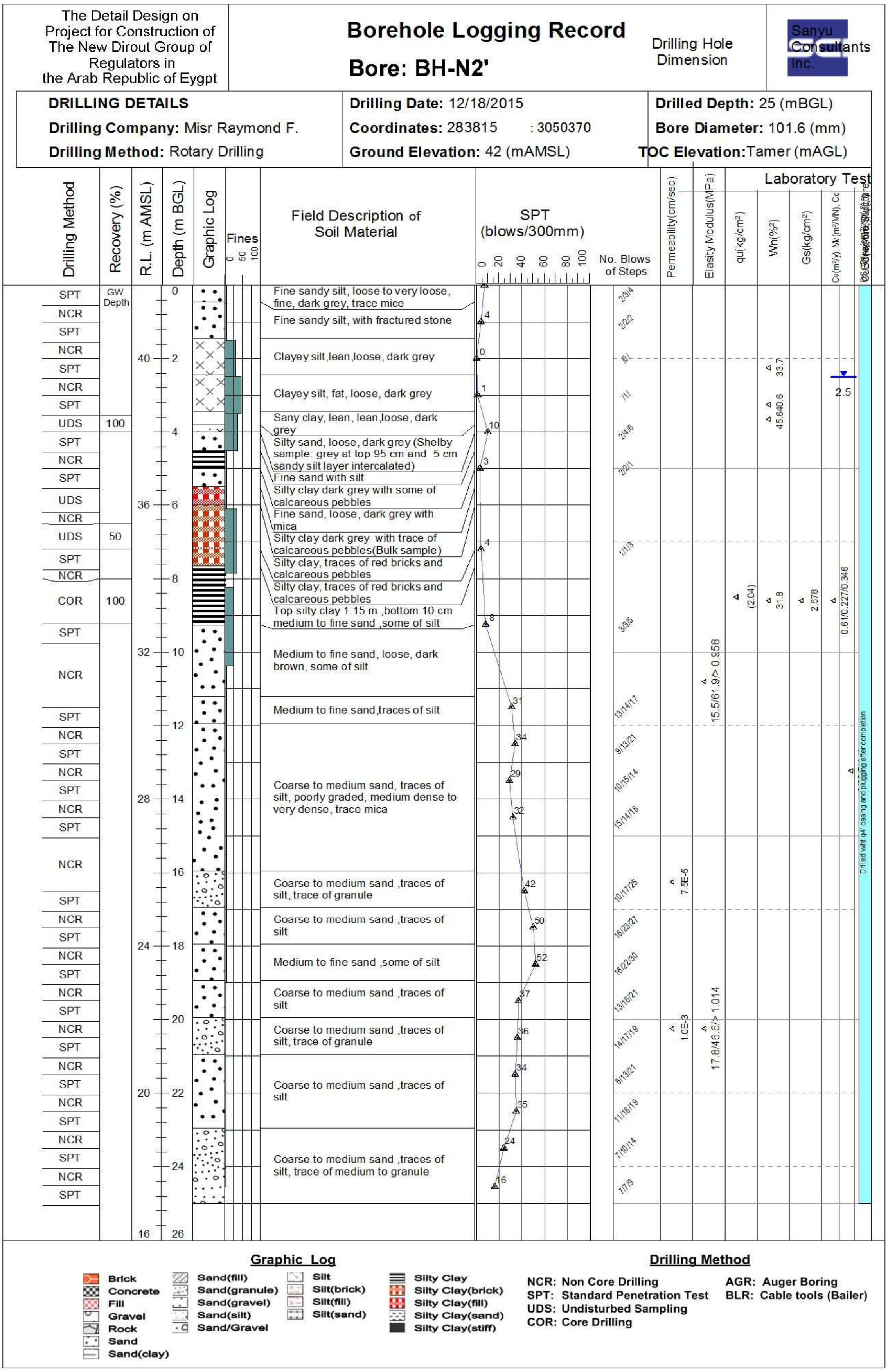

The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt
Borehole Logging Record
Bore: BH-N2'
Drilling Hole Dimension
Sanyu Consultants Inc.
DRILLING DETAILS
Drilling Company: Misr Raymond F.
Drilling Method: Rotary Drilling
Drilling Date: 12/18/2015
Coordinates: 283815 : 3050370
Ground Elevation: 42 (mAMSL)
Drilled Depth: 25 (mBGL)
Bore Diameter: 101.6 (mm)
TOC Elevation:Tamer (mAGL)
Drilling Method
Recovery (%)
R.L. (m AMSL)
Depth (m BGL)
Graphic Log
Fines
0 50 100
Field Description of Soil Material
SPT (blows/300mm)
0 20 40 60 80 100
No. Blows of Steps
Permeability(cm/sec)
Elasity Modulus(MPa)
Laboratory Test
qu(kg/cm²)
Wn(%²)
Gs(kg/cm²)
Cv(m²/y), Mv (m²/MN), Cc
SPT NCR SPT NCR SPT NCR SPT UDS SPT NCR SPT UDS NCR UDS SPT NCR COR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT NCR SPT
GW Depth
100
50
100
40 36 32 28 24 20 16
0 2 4 6 8 10 12 14 16 18 20 22 24 26
Fine sandy silt, loose to very loose, fine, dark grey, trace mice
Fine sandy silt, with fractured stone
Clayey silt,lean,loose, dark grey
Clayey silt, fat, loose, dark grey
Sany clay, lean, lean,loose, dark grey
Silty sand, loose, dark grey (Shelby sample: grey at top 95 cm and 5 cm sandy silt layer intercalated)
Fine sand with silt
Silty clay dark grey with some of calcareous pebbles
Fine sand, loose, dark grey with mica
Silty clay dark grey with trace of calcareous pebbles(Bulk sample)
Silty clay, traces of red bricks and calcareous pebbles
Silty clay, traces of red bricks and calcareous pebbles
Top silty clay 1.15 m ,bottom 10 cm medium to fine sand ,some of silt
Medium to fine sand, loose, dark brown, some of silt
Medium to fine sand,traces of silt
Coarse to medium sand, traces of silt, poorly graded, medium dense to very dense, trace mica
Coarse to medium sand ,traces of silt, trace of granule
Coarse to medium sand ,traces of silt
Medium to fine sand ,some of silt
Coarse to medium sand ,traces of silt
Coarse to medium sand ,traces of silt, trace of granule
Coarse to medium sand ,traces of silt
Coarse to medium sand ,traces of silt, trace of medium to granule
4 0 1 10 3 4 8 31 34 29 32 42 50 52 37 36 34 35 24 16
2/3/4 2/2/2 /0/ /1/ 2/4/6 2/2/1 1/1/3 3/3/5 13/14/17 9/13/21 10/15/14 15/14/18 10/17/25 16/23/27 16/22/30 13/16/21 14/17/19 8/13/21 11/16/19 7/10/14 7/7/9
7.5E-5
1.0E-3
15.5/61.9/> 0.958
17.8/46.6/> 1.014
(2.04)
33.7
45.6
40.6
31.8
2.678
0.61/0.227/0.346
2.5
Drilled with φ4' casing and plugging after completion
Graphic Log
Brick
Concrete
Fill
Gravel
Rock
Sand
Sand(clay)
Sand(fill)
Sand(granule)
Sand(gravel)
Sand(silt)
Sand/Gravel
Silt
Silt(brick)
Silt(fill)
Silt(sand)
Silty Clay
Silty Clay(brick)
Silty Clay(fill)
Silty Clay(sand)
Silty Clay(stiff)
Drilling Method
NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.7 Borehole log (BH-N2')

The Detail Design on
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Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N2A

Drilling Hole
Dimension

Sanyu
Consultants
Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 12/31/2015

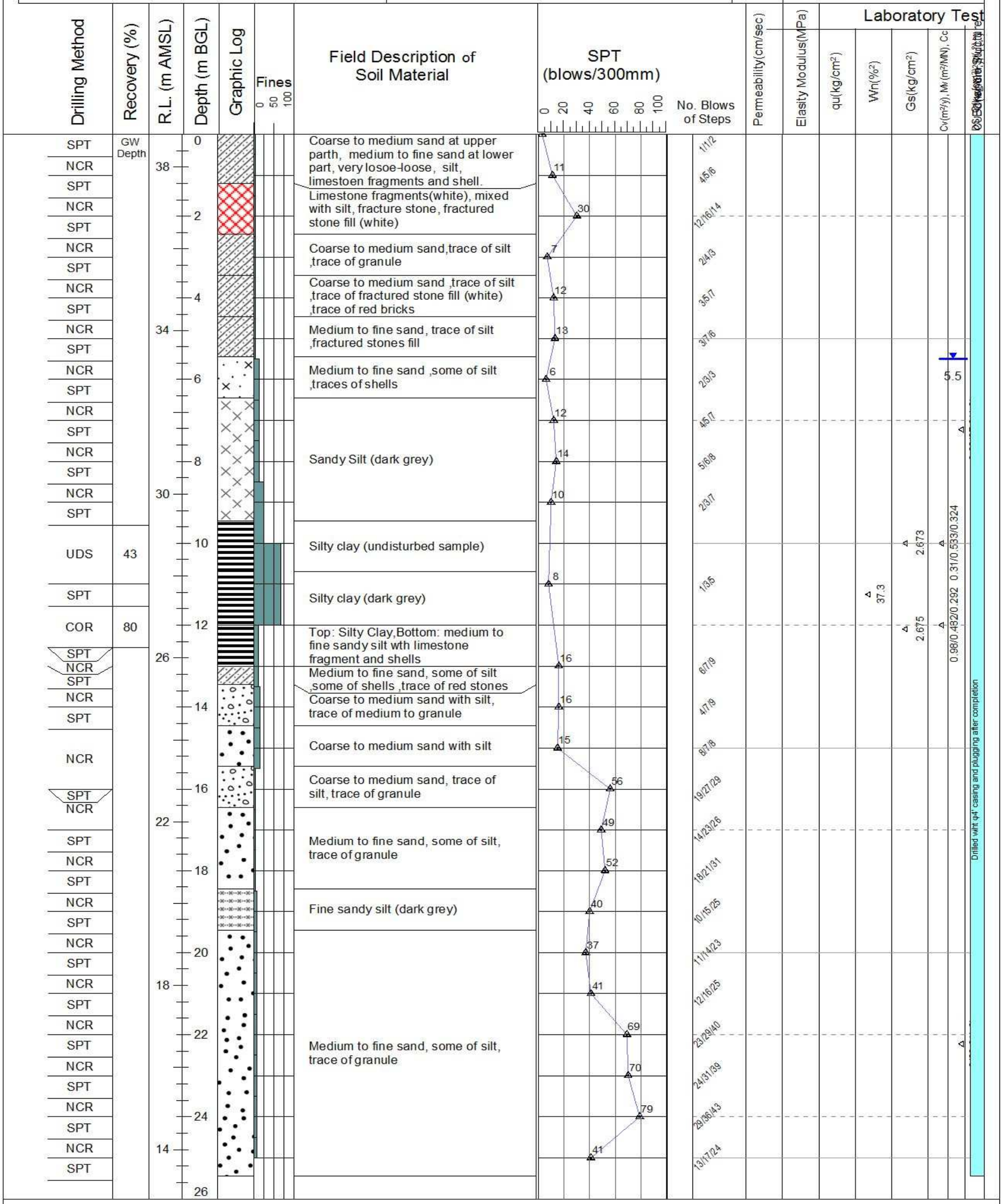
Coordinates: 283774 : 3050340

Ground Elevation: 38.8 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)



Coarse to medium sand at upper parth, medium to fine sand at lower part, very losoe-loose, silt, limestoen fragments and shell.

Limestone fragments(white), mixed with silt, fracture stone, fractured stone fill (white)

Coarse to medium sand,trace of silt ,trace of granule

Coarse to medium sand ,trace of silt ,trace of fractured stone fill (white) ,trace of red bricks

Medium to fine sand, trace of silt ,fractured stones fill

Medium to fine sand ,some of silt ,traces of shells

Sandy Silt (dark grey)

Silty clay (undisturbed sample)

Silty clay (dark grey)

Top: Silty Clay,Bottom: medium to fine sandy silt wth limestone fragment and shells

Medium to fine sand, some of silt ,some of shells ,trace of red stones

Coarse to medium sand with silt, trace of medium to granule

Coarse to medium sand with silt

Coarse to medium sand, trace of silt, trace of granule

Medium to fine sand, some of silt, trace of granule

Fine sandy silt (dark grey)

Medium to fine sand, some of silt, trace of granule

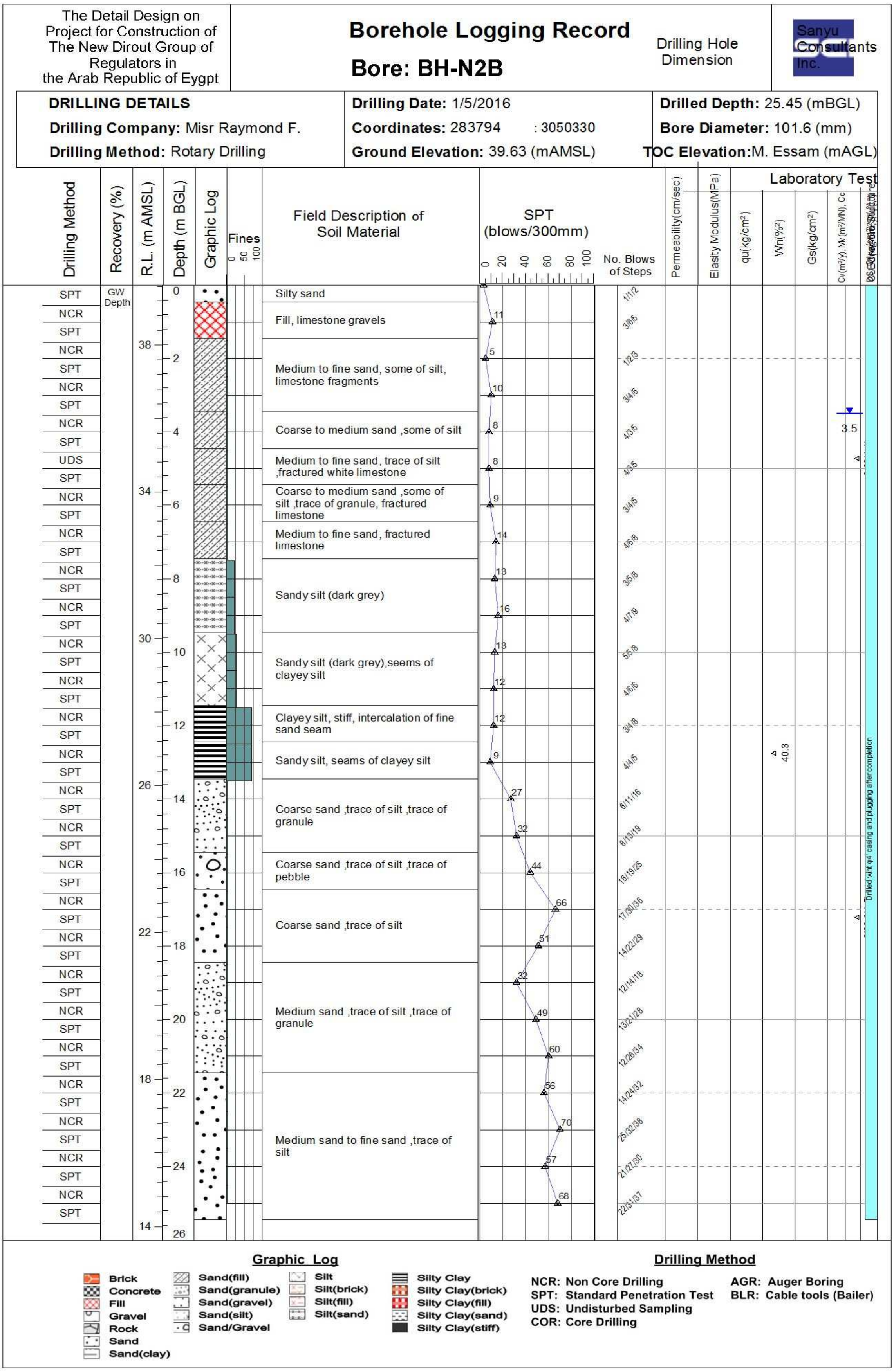
Graphic Log

- Brick
- Concrete
- Fill
- Gravel
- Rock
- Sand
- Sand(clay)
- Sand(fill)
- Sand(granule)
- Sand(gravel)
- Sand(silt)
- Sand/Gravel
- Silt
- Silt(brick)
- Silt(fill)
- Silt(sand)
- Silty Clay
- Silty Clay(brick)
- Silty Clay(fill)
- Silty Clay(sand)
- Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.8 Borehole log (BH-N2A)



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N2B

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 1/5/2016

Coordinates: 283794 : 3050330

Ground Elevation: 39.63 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation: M. Essam (mAGL)

Drilling Method: SPT, NCR, SPT, NCR, SPT, NCR, SPT, NCR, SPT, UDS, SPT, NCR, SPT

Field Description of Soil Material:

- Silty sand
- Fill, limestone gravels
- Medium to fine sand, some of silt, limestone fragments
- Coarse to medium sand ,some of silt
- Medium to fine sand, trace of silt ,fractured white limestone
- Coarse to medium sand ,some of silt ,trace of granule, fractured limestone
- Medium to fine sand, fractured limestone
- Sandy silt (dark grey)
- Sandy silt (dark grey),seems of clayey silt
- Clayey silt, stiff, intercalation of fine sand seam
- Sandy silt, seams of clayey silt
- Coarse sand ,trace of silt ,trace of granule
- Coarse sand ,trace of silt ,trace of pebble
- Coarse sand ,trace of silt
- Medium sand ,trace of silt ,trace of granule
- Medium sand to fine sand ,trace of silt

SPT (blows/300mm)	No. Blows of Steps
	1/1/2
11	3/6/5
5	1/2/3
10	3/4/6
8	4/3/5
8	4/3/5
9	3/4/5
14	4/6/8
13	3/5/8
16	4/7/9
13	5/5/8
12	4/6/6
12	3/4/8
9	4/4/5
27	6/11/16
32	8/13/19
44	16/19/25
66	17/30/36
51	14/22/29
32	12/14/18
49	13/21/28
60	12/26/34
56	14/24/32
70	25/32/38
57	21/27/30
68	22/31/37

Graphic Log

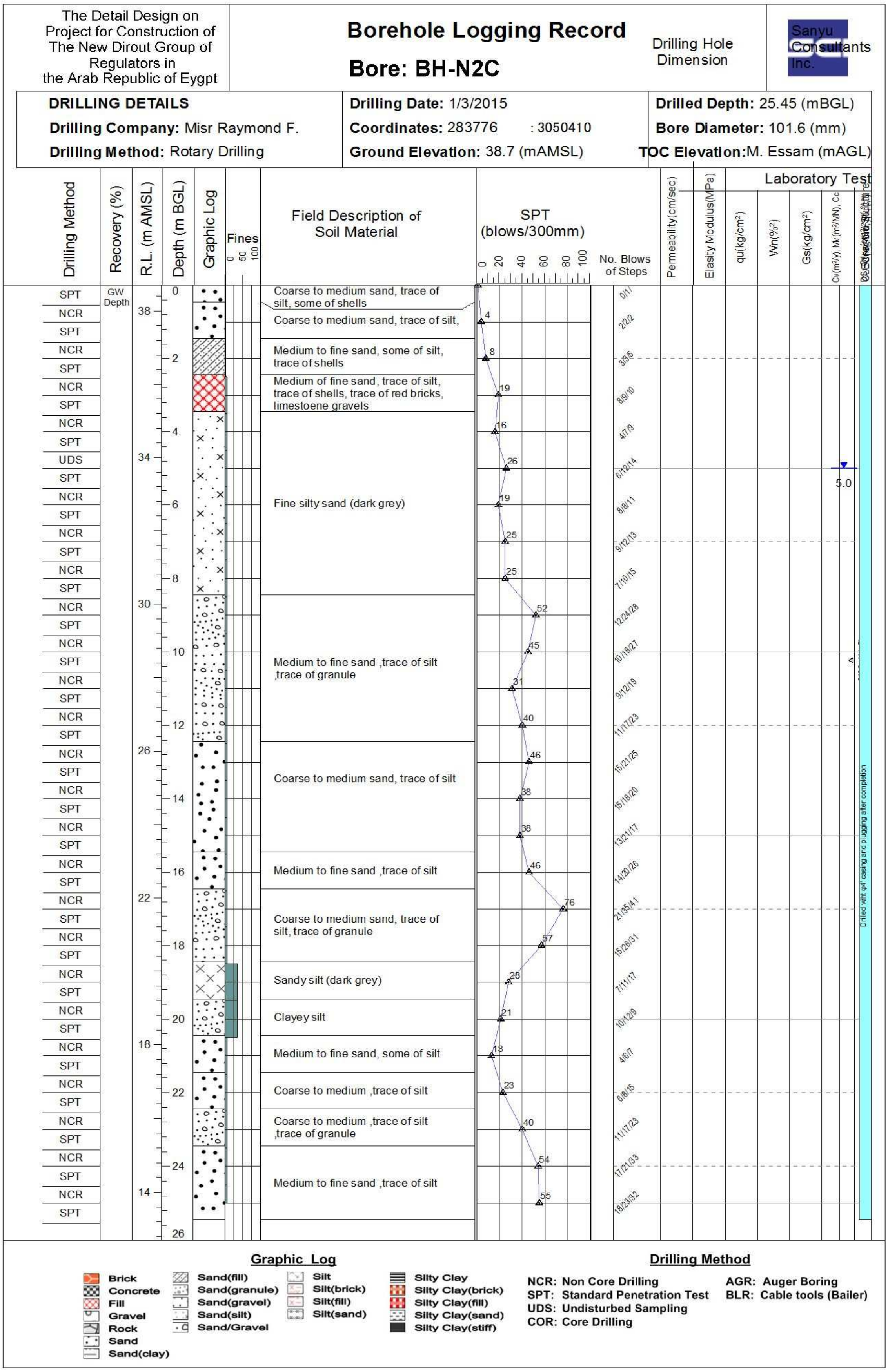
Brick	Sand(fill)	Silt
Concrete	Sand(granule)	Silt(brick)
Fill	Sand(gravel)	Silt(fill)
Gravel	Sand(silt)	Silt(sand)
Rock	Sand/Gravel	
Sand		
Sand(clay)		

Silty Clay
Silty Clay(brick)
Silty Clay(fill)
Silty Clay(sand)
Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.9 Borehole log (BH-N2B)



The Detail Design on
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Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N2C

Drilling Hole
Dimension

Sanyu
Consultants
Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 1/3/2015

Coordinates: 283776　: 3050410

Ground Elevation: 38.7 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Field Description of Soil Material:

- Coarse to medium sand, trace of silt, some of shells
- Coarse to medium sand, trace of silt,
- Medium to fine sand, some of silt, trace of shells
- Medium of fine sand, trace of silt, trace of shells, trace of red bricks, limestoene gravels
- Fine silty sand (dark grey)
- Medium to fine sand ,trace of silt ,trace of granule
- Coarse to medium sand, trace of silt
- Medium to fine sand ,trace of silt
- Coarse to medium sand, trace of silt, trace of granule
- Sandy silt (dark grey)
- Clayey silt
- Medium to fine sand, some of silt
- Coarse to medium ,trace of silt
- Coarse to medium ,trace of silt ,trace of granule
- Medium to fine sand ,trace of silt

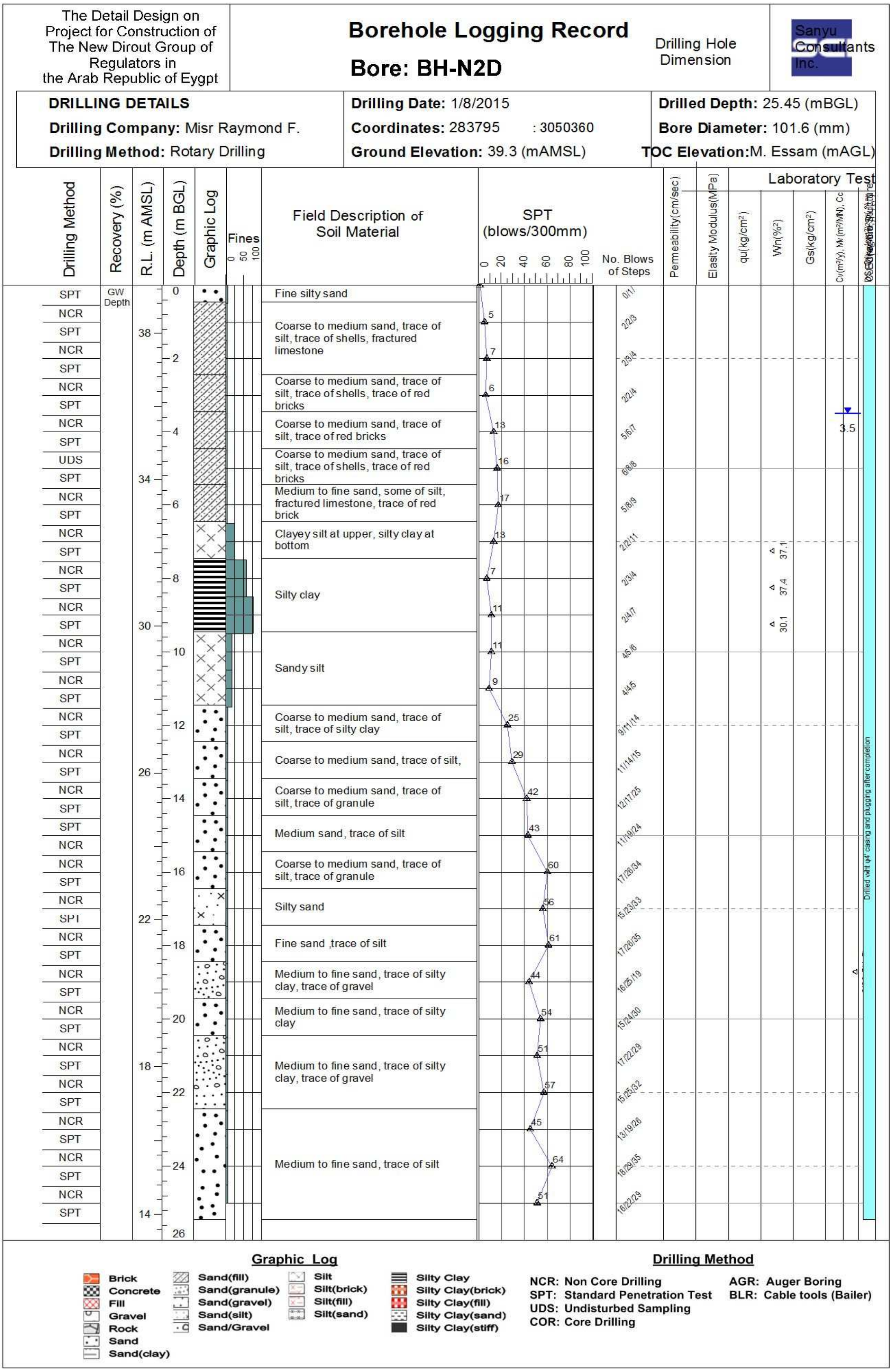
Drilling Method	SPT (blows/300mm)	No. Blows of Steps
SPT		0/1/
NCR		
SPT	4	2/2/2
NCR		
SPT	8	3/3/5
NCR		
SPT	19	8/9/10
NCR		
SPT	16	4/7/9
UDS		
SPT	26	6/12/14
NCR		
SPT	19	8/8/11
NCR		
SPT	25	9/12/13
NCR		
SPT	25	7/10/15
NCR		
SPT	52	12/24/28
NCR		
SPT	45	10/18/27
NCR		
SPT	31	9/12/19
NCR		
SPT	40	11/17/23
NCR		
SPT	46	15/21/25
NCR		
SPT	38	15/18/20
NCR		
SPT	38	13/21/17
NCR		
SPT	46	14/20/26
NCR		
SPT	76	21/35/41
NCR		
SPT	57	15/26/31
NCR		
SPT	28	7/11/17
NCR		
SPT	21	10/12/9
NCR		
SPT	13	4/6/7
NCR		
SPT	23	6/8/15
NCR		
SPT	40	11/17/23
NCR		
SPT	54	17/21/33
NCR		
SPT	55	18/23/32

Graphic Log

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.10 Borehole log (BH-N2C)



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N2D

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 1/8/2015

Coordinates: 283795 : 3050360

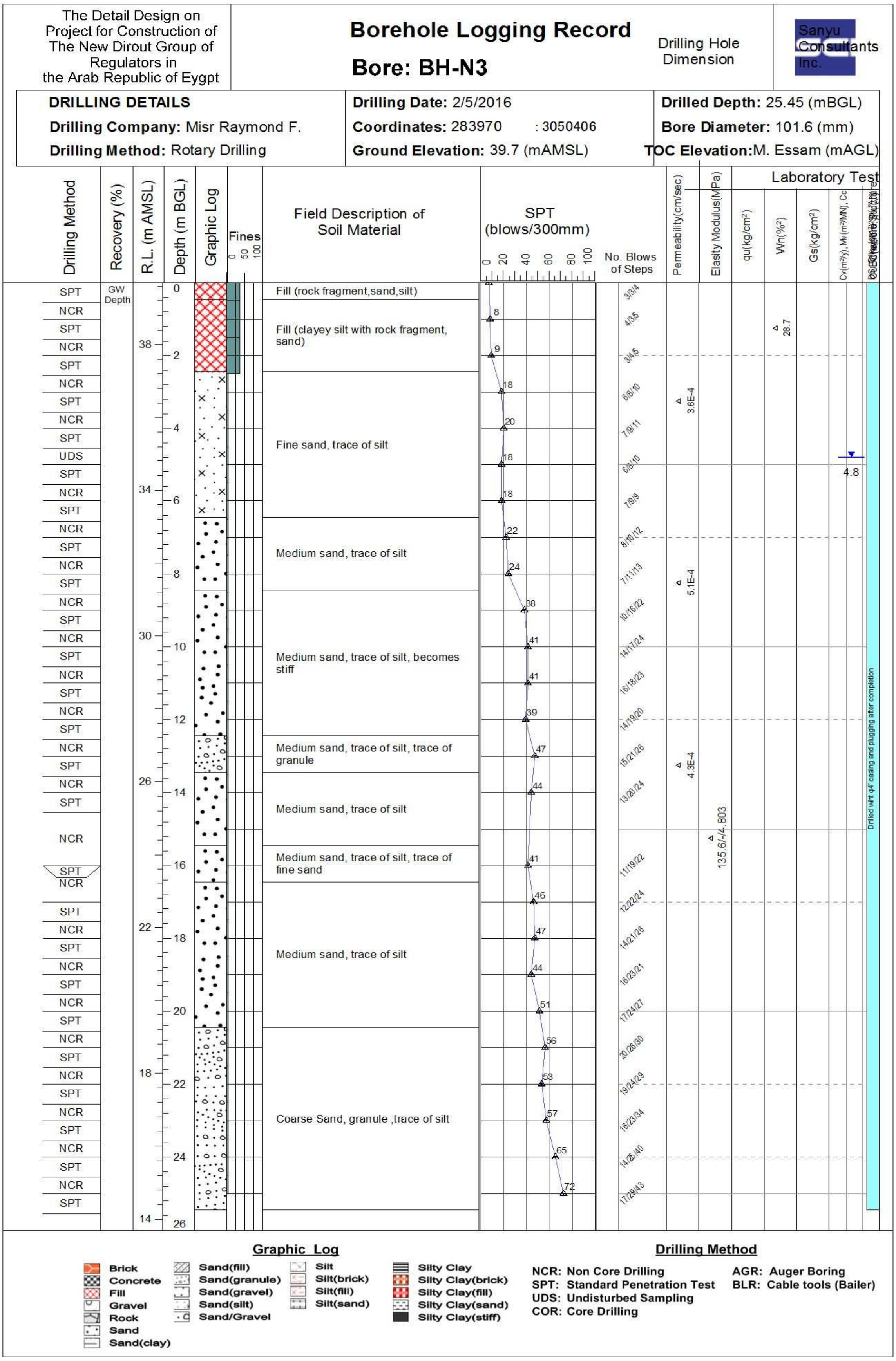
Ground Elevation: 39.3 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Figure 2-3.11 Borehole log (BH-N2D)



The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Egypt

Borehole Logging Record

Bore: BH-N3

Drilling Hole
Dimension

Sanyu
Consultants
Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/5/2016

Coordinates: 283970 : 3050406

Ground Elevation: 39.7 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Field Description of Soil Material
Fill (rock fragment,sand,silt)
Fill (clayey silt with rock fragment, sand)
Fine sand, trace of silt
Medium sand, trace of silt
Medium sand, trace of silt, becomes stiff
Medium sand, trace of silt, trace of granule
Medium sand, trace of silt
Medium sand, trace of silt, trace of fine sand
Medium sand, trace of silt
Coarse Sand, granule ,trace of silt

SPT (blows/300mm)	No. Blows of Steps
	3/3/4
8	4/3/5
9	3/4/5
18	6/8/10
20	7/9/11
18	6/8/10
18	7/9/9
22	8/10/12
24	7/11/13
38	10/16/22
41	14/17/24
41	16/18/23
39	14/19/20
47	15/21/26
44	13/20/24
41	11/19/22
46	12/22/24
47	14/21/26
44	16/23/21
51	17/24/27
56	20/26/30
53	19/24/29
57	16/23/34
65	14/25/40
72	17/29/43

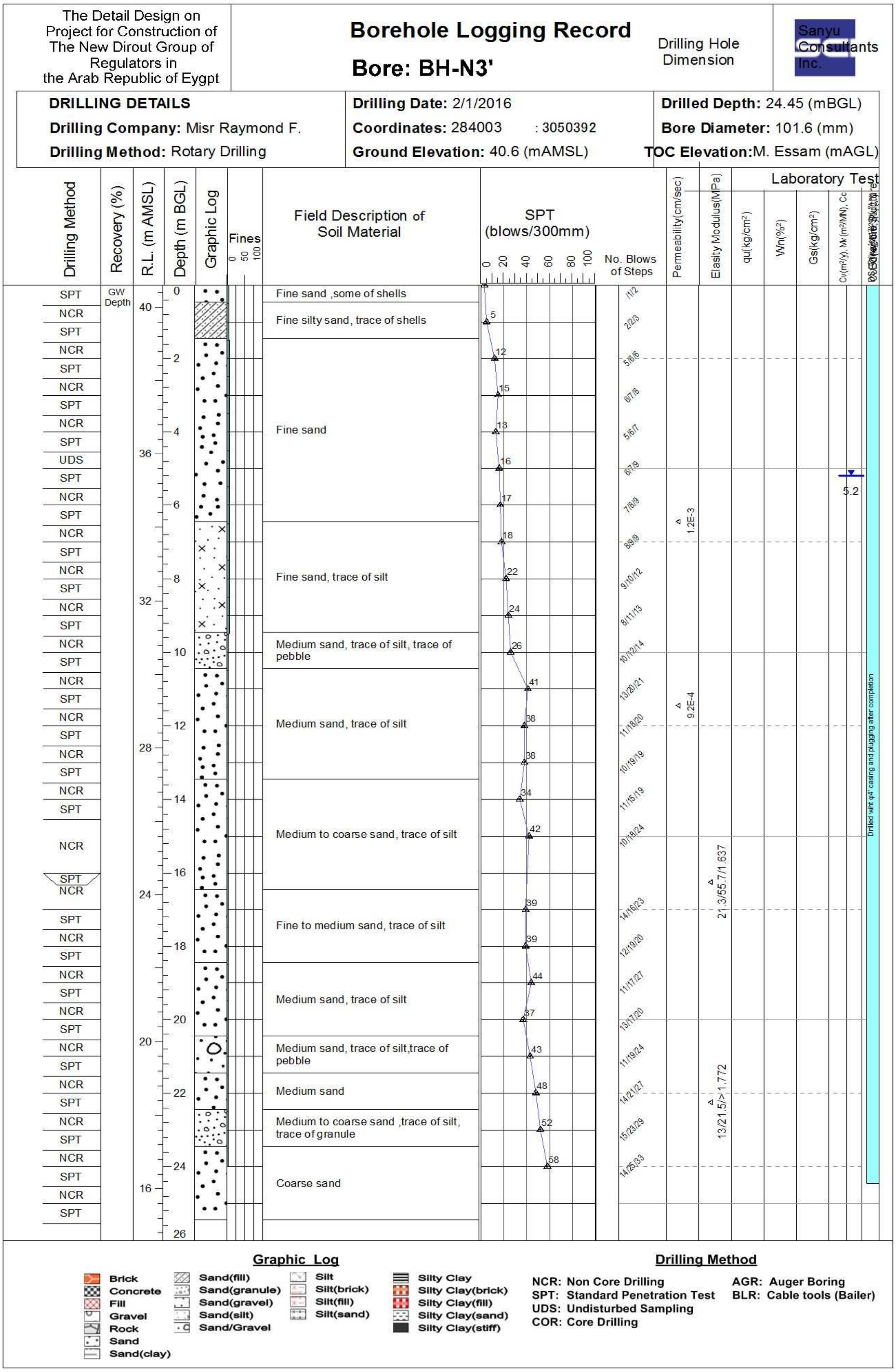
Graphic Log

- Brick
- Concrete
- Fill
- Gravel
- Rock
- Sand
- Sand(clay)
- Sand(fill)
- Sand(granule)
- Sand(gravel)
- Sand(silt)
- Sand/Gravel
- Silt
- Silt(brick)
- Silt(fill)
- Silt(sand)
- Silty Clay
- Silty Clay(brick)
- Silty Clay(fill)
- Silty Clay(sand)
- Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.12 Borehole log (BH-N3)



The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N3'

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/1/2016

Coordinates: 284003 : 3050392

Ground Elevation: 40.6 (mAMSL)

Drilled Depth: 24.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Field Description of Soil Material

- Fine sand ,some of shells
- Fine silty sand, trace of shells
- Fine sand
- Fine sand, trace of silt
- Medium sand, trace of silt, trace of pebble
- Medium sand, trace of silt
- Medium to coarse sand, trace of silt
- Fine to medium sand, trace of silt
- Medium sand, trace of silt
- Medium sand, trace of silt,trace of pebble
- Medium sand
- Medium to coarse sand ,trace of silt, trace of granule
- Coarse sand

Drilled wiht φ4' casing and plugging after completion

Graphic Log

Brick	Sand(fill)	Silt
Concrete	Sand(granule)	Silt(brick)
Fill	Sand(gravel)	Silt(fill)
Gravel	Sand(silt)	Silt(sand)
Rock	Sand/Gravel	
Sand		
Sand(clay)		

Silty Clay
Silty Clay(brick)
Silty Clay(fill)
Silty Clay(sand)
Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.13 Borehole log (BH-N3')

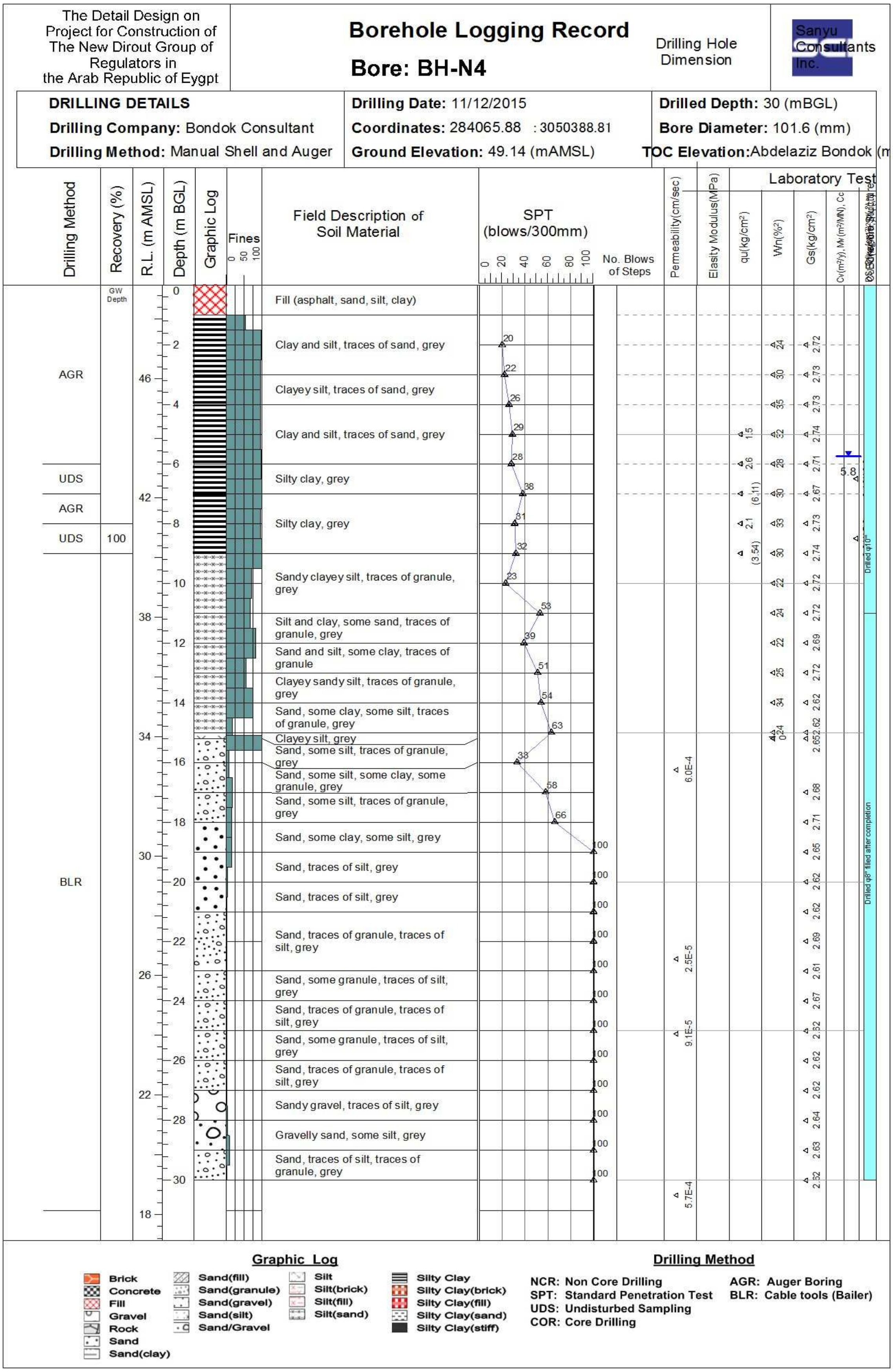


Figure 2-3.14 Borehole log (BH-N4)

The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N4*

Drilling Hole
Dimension

Sanyu
Consultants
Inc.

DRILLING DETAILS

Drilling Company: Bondok Consultant

Drilling Method: Rotary Drilling

Drilling Date: 11/12/2015

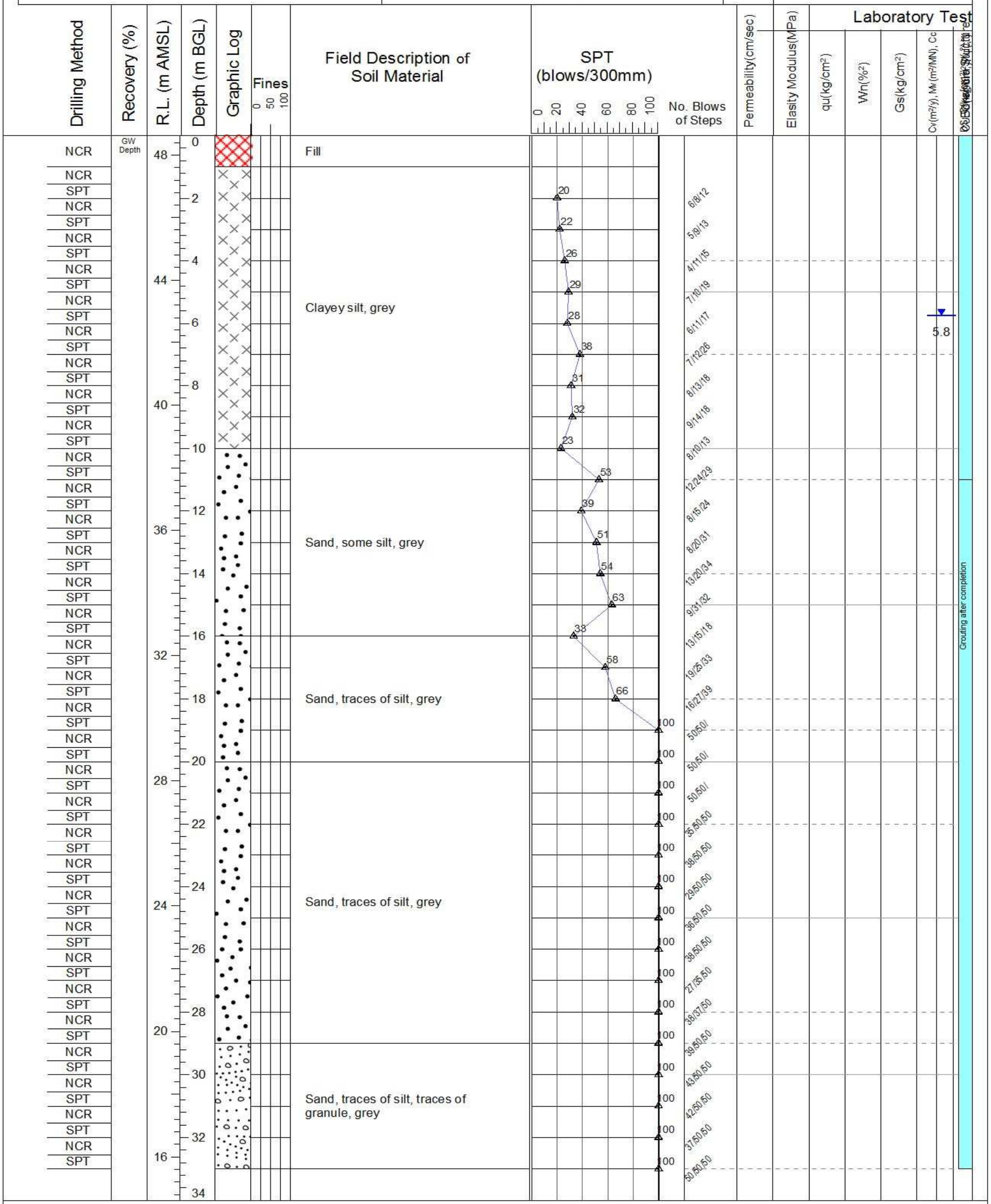
Coordinates: 284081.46 : 3050383.18

Ground Elevation: 48.62 (mAMSL)

Drilled Depth: 33 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation: Abdelaziz Bondok (m



Fill

Clayey silt, grey

Sand, some silt, grey

Sand, traces of silt, grey

Sand, traces of silt, grey

Sand, traces of silt, traces of granule, grey

SPT (blows/300mm)	No. Blows of Steps
20	6/8/12
22	5/9/13
26	4/11/15
29	7/10/19
28	6/11/17
38	7/12/26
31	8/13/18
32	9/14/18
23	8/10/13
53	12/24/29
39	8/15/24
51	8/20/31
54	13/20/34
63	9/31/32
33	13/15/18
58	19/25/33
66	16/27/39
100	50/50/
100	50/50/
100	50/50/
100	35/50/50
100	38/50/50
100	29/50/50
100	36/50/50
100	38/50/50
100	27/35/50
100	38/37/50
100	39/50/50
100	43/50/50
100	42/50/50
100	37/50/50
100	50/50/50

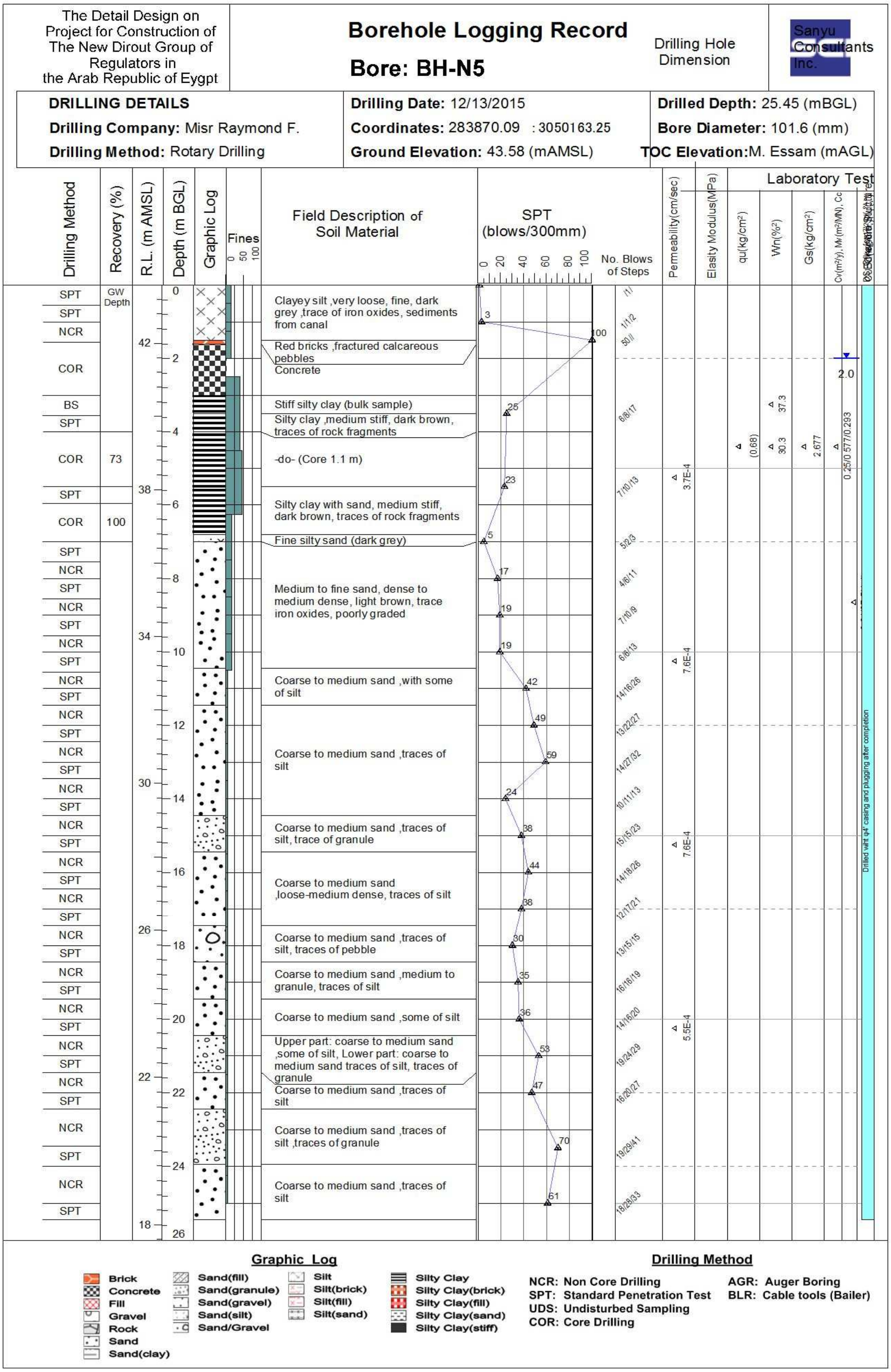
Graphic Log

- Brick
- Concrete
- Fill
- Gravel
- Rock
- Sand
- Sand(clay)
- Sand(fill)
- Sand(granule)
- Sand(gravel)
- Sand(silt)
- Sand/Gravel
- Silt
- Silt(brick)
- Silt(fill)
- Silt(sand)
- Silty Clay
- Silty Clay(brick)
- Silty Clay(fill)
- Silty Clay(sand)
- Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.15 Borehole log (BH-N4*)



The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N5

Drilling Hole
Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 12/13/2015

Coordinates: 283870.09 : 3050163.25

Ground Elevation: 43.58 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation: M. Essam (mAGL)

Field Description of Soil Material

Clayey silt ,very loose, fine, dark grey ,trace of iron oxides, sediments from canal

Red bricks ,fractured calcareous pebbles

Concrete

Stiff silty clay (bulk sample)

Silty clay ,medium stiff, dark brown, traces of rock fragments

-do- (Core 1.1 m)

Silty clay with sand, medium stiff, dark brown, traces of rock fragments

Fine silty sand (dark grey)

Medium to fine sand, dense to medium dense, light brown, trace iron oxides, poorly graded

Coarse to medium sand ,with some of silt

Coarse to medium sand ,traces of silt

Coarse to medium sand ,traces of silt, trace of granule

Coarse to medium sand ,loose-medium dense, traces of silt

Coarse to medium sand ,traces of silt, traces of pebble

Coarse to medium sand ,medium to granule, traces of silt

Coarse to medium sand ,some of silt

Upper part: coarse to medium sand ,some of silt, Lower part: coarse to medium sand traces of silt, traces of granule

Coarse to medium sand ,traces of silt

Coarse to medium sand ,traces of silt ,traces of granule

Coarse to medium sand ,traces of silt

Drilled wiht φ4' casing and plugging after completion

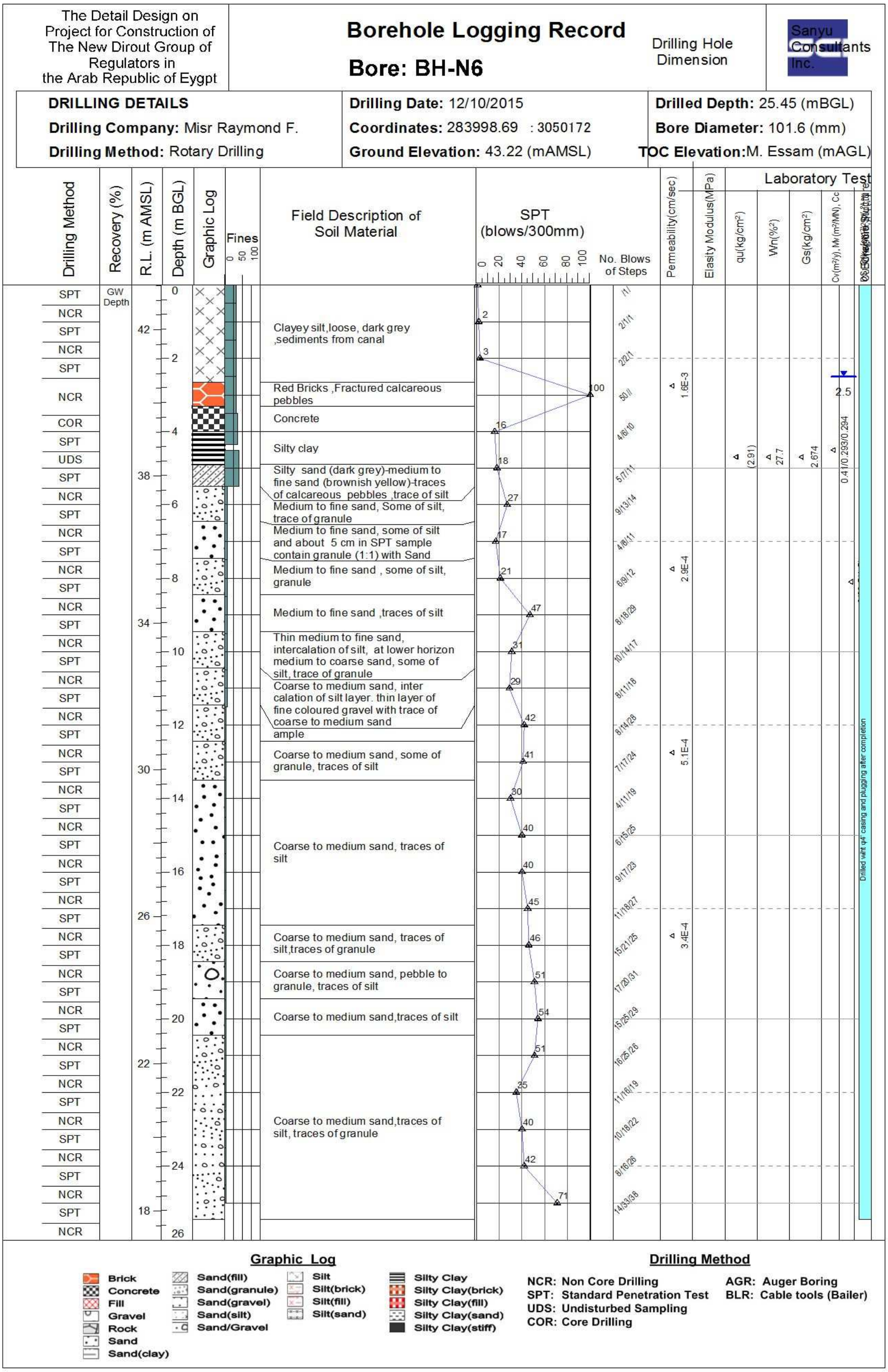
Graphic Log

- ▨ Brick
- ▦ Concrete
- ▨ Fill
- ▭ Gravel
- ▨ Rock
- ▭ Sand
- ▭ Sand(clay)
- ▨ Sand(fill)
- ▭ Sand(granule)
- ▭ Sand(gravel)
- ▭ Sand(silt)
- ▭ Sand/Gravel
- ▭ Silt
- ▭ Silt(brick)
- ▭ Silt(fill)
- ▭ Silt(sand)
- ☰ Silty Clay
- ▦ Silty Clay(brick)
- ▦ Silty Clay(fill)
- ▭ Silty Clay(sand)
- ■ Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.16 Borehole log (BH-N5)



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N6

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 12/10/2015

Coordinates: 283998.69 : 3050172

Ground Elevation: 43.22 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation: M. Essam (mAGL)

Field Description of Soil Material

Clayey silt,loose, dark grey ,sediments from canal

Red Bricks ,Fractured calcareous pebbles

Concrete

Silty clay

Silty sand (dark grey)-medium to fine sand (brownish yellow)-traces of calcareous pebbles ,trace of silt

Medium to fine sand, Some of silt, trace of granule

Medium to fine sand, some of silt and about 5 cm in SPT sample contain granule (1:1) with Sand

Medium to fine sand , some of silt, granule

Medium to fine sand ,traces of silt

Thin medium to fine sand, intercalation of silt, at lower horizon medium to coarse sand, some of silt, trace of granule

Coarse to medium sand, inter calation of silt layer. thin layer of fine coloured gravel with trace of coarse to medium sand ample

Coarse to medium sand, some of granule, traces of silt

Coarse to medium sand, traces of silt

Coarse to medium sand, traces of silt,traces of granule

Coarse to medium sand, pebble to granule, traces of silt

Coarse to medium sand,traces of silt

Coarse to medium sand,traces of silt, traces of granule

Drilled wiht φ4' casing and plugging after completion

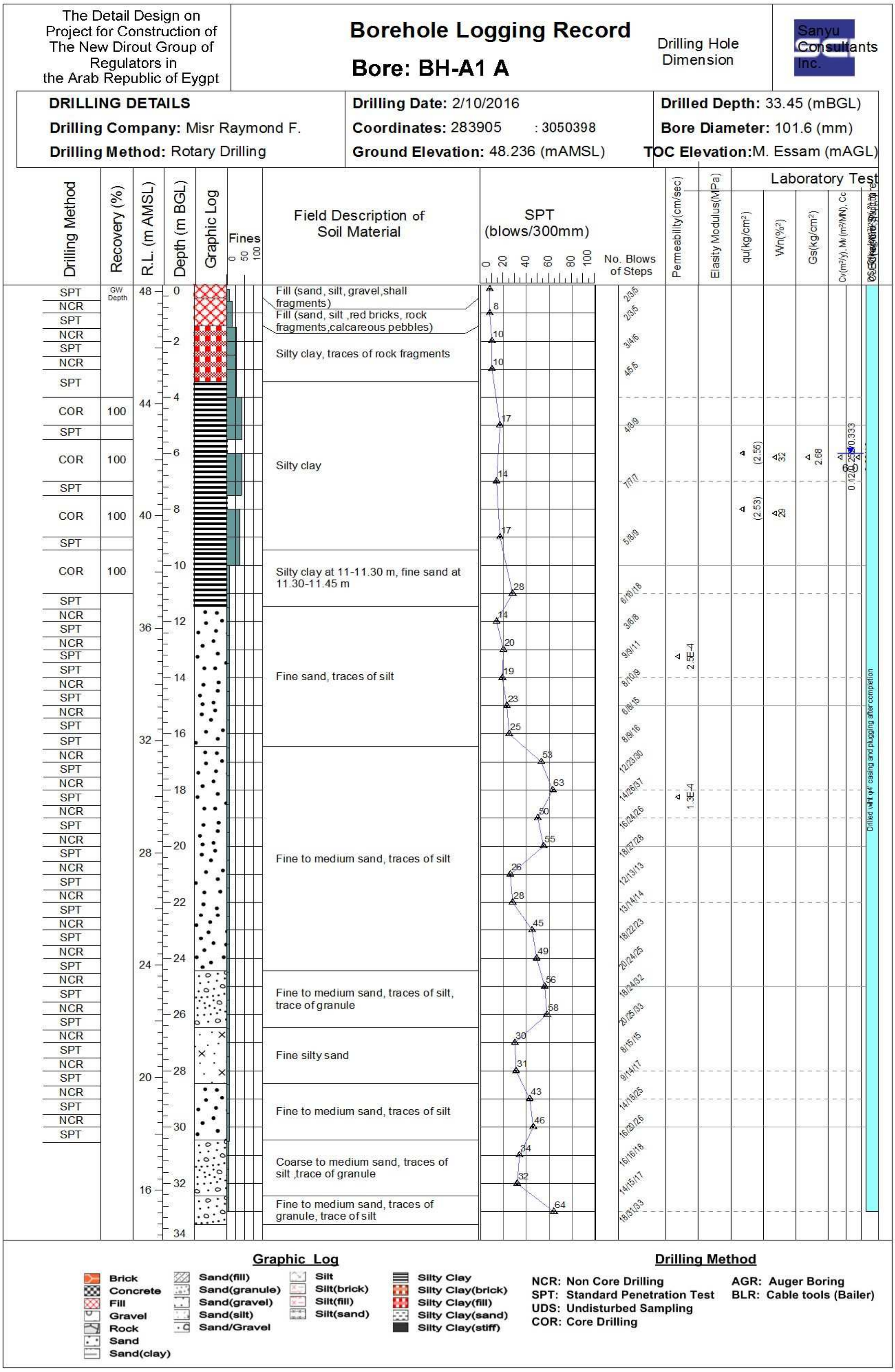
Graphic Log

▨ Brick
▨ Concrete
▨ Fill
▨ Gravel
▨ Rock
▨ Sand
▨ Sand(clay)
▨ Sand(fill)
▨ Sand(granule)
▨ Sand(gravel)
▨ Sand(silt)
▨ Sand/Gravel
▨ Silt
▨ Silt(brick)
▨ Silt(fill)
▨ Silt(sand)
▨ Silty Clay
▨ Silty Clay(brick)
▨ Silty Clay(fill)
▨ Silty Clay(sand)
▨ Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.17 Borehole log (BH-N6)



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-A1 A

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/10/2016

Coordinates: 283905 : 3050398

Ground Elevation: 48.236 (mAMSL)

Drilled Depth: 33.45 (mBGL)

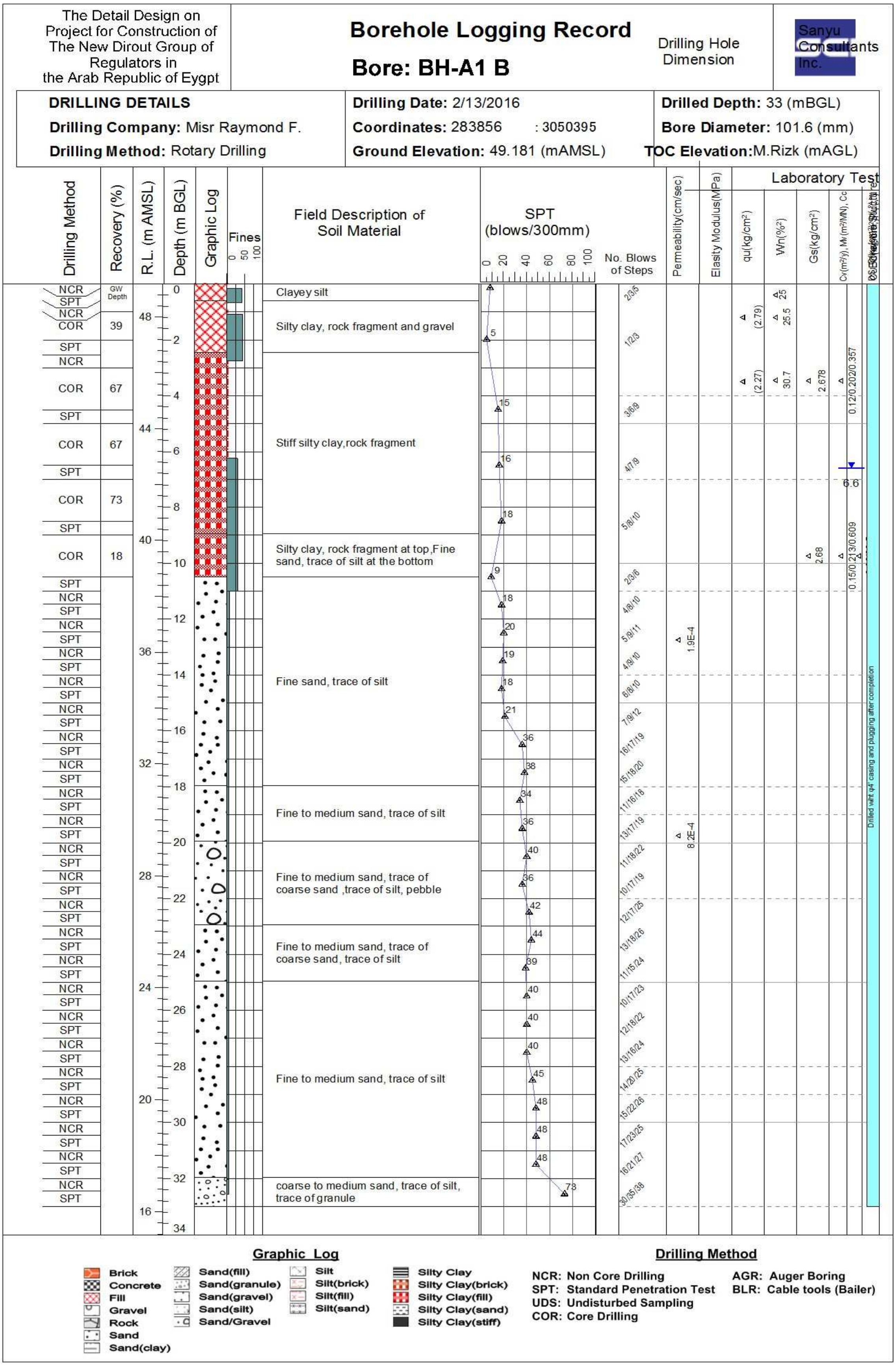
Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure 2-3.18 Borehole log (BH-A1A)



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-A1 B

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/13/2016

Coordinates: 283856 : 3050395

Ground Elevation: 49.181 (mAMSL)

Drilled Depth: 33 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M.Rizk (mAGL)

Figure 2-3.19 Borehole log (BH-A1B)

3. Hydraulic Dimensions and Calculation

3-1 Purpose

In order to clarify the flow capacity of the canal, a non-uniform flow analysis was applied under design conditions. Effective waterhead, is the difference between the upstream of the high water level (US.HWL) and the downstream of the high water level (DS.HWL).

In the evaluation of the analysis, the calculated water level at the end of the upstream must be lower than US.HWL under the conditions of the maximum discharge flow, with DS.HWL as the starting point for calculations. A water head shortage is found when US. HWL is calculated.

3-2 Hydraulic calculation (Non-uniform flow analysis)

(1) Method of analysis

Tracking the water surface in non-uniform flow is carried out by solving the basic equations of non-uniform flow, using the stepwise calculation method, or the graphical method. Calculations are carried out from a given point; toward the upstream side in the case of steady flow to the downstream side in the case of rapid flow.

Stepwise calculation method assumes the water depths at successive points from a given point, and the calculation proceeds verifying the energy by applying Bernoulli’s theory. This method has many merits: (1) calculation can be carried out at any cross-section regardless of rate of flow, (2) losses other than those incurred by friction can be calculated. It is therefore the most widely used computerized method. By dividing the water channel into ideal calculation sections and applying boundary conditions at the nodes, the calculation is carried out to obtain the successive shape of the water surface so that Bernoulli’s equation is satisfied in each section. Applying Bernoulli’s equation to cross-sections I and II in Figure 3-2.1, the following equations are obtained.

$$h_1+\frac{\alpha\cdot Q^2}{2g\cdot A_1{}^2}+z_1+h_f=h_2+\frac{\alpha\cdot Q^2}{2g\cdot A_2{}^2}+z_2$$

$$h_f=\frac{Q^2\cdot l}{2}\left(\frac{n_1{}^2}{R_1{}^{4/3}A_1{}^2}+\frac{n_2{}^2}{R_2{}^{4/3}A_2{}^2}\right)$$

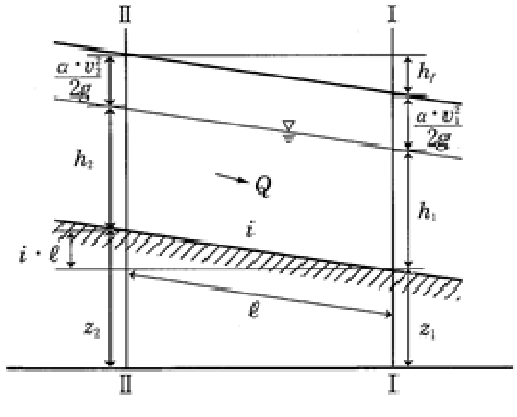

II
I
h_f
$\frac{\alpha\cdot v_2^2}{2g}$
$\frac{\alpha\cdot v_1^2}{2g}$
h_2
h_1
Q
i
$i\cdot\ell$
ℓ
z_2
z_1
II
I

Figure 3-2.1 Explanatory drawing for non-uniform flow calculation

Where, z : Height from bedrock to bottom of water channel (m)

h : Water depth (m)

Q : Discharge (m^3/s)
v : Flow velocity (Q/A) (m/s)
i : Slope of the water channel bottom
h_f : Water head loss produced at cross-sections I, II (m)
ℓ : Slope length between cross-sections I to II (m)
R : Hydraulic radius (m)
A : Area of cross-section of water (m^2)
n : Roughness coefficient
g : Gravitational acceleration 9.8 (m/s^2)
α : Energy correction function
Subscripts 1, 2: indicate values at cross-sections 1 and 2 respectively.

When the energy at cross-section I is given, the water depth is calculated at cross-section II so that adding the hydraulic head loss between cross-sections I and II to the height of this energy line gives the height at cross-section II.

(2) Result of calculations

The result of required upstream-water level calculations by non-uniform analysis is shown on Table 3-2.1.

Table 3-2.1 Result of calculation by non-uniform analysis

Reg.name	**Bahr Yusef**	**Ibrahimia**	**Badraman**		**Abo Gabal**		**Sahelyia**
Canal name			**Badraman**	**Diroutiah**	**Abo Gabal**	**Irad Delgaw**	
Qmax	227 m^3/s	186 m^3/s	9 m^3/s	12 m^3/s	7 m^3/s	9 m^3/s	5 m^3/s
DS.HWL	45.82 m	45.13 m	45.90 m	45.90 m	45.90 m	45.90 m	45.90 m
Required US. water level (calculated WL)	46.00 m	45.22 m	45.96 m	45.95 m	45.94 m	45.95 m	45.93 m
US.HWL	< 46.30 m	< 46.30 m	< 46.30 m	< 46.30 m	< 46.30 m	< 46.30 m	< 46.30 m
Judgment	**O.K**	**O.K**	**O.K**	**O.K**	**O.K**	**O.K**	**O.K**

4. Determining the Regulator Axis

4-1 Background related to determining the regulator axis

(1) Review of the regulators axis selection in the F/S stage

When the regulator axis was studied in F/S stage in 2010, there were two examination steps; namely, preliminary and detailed examinations.

1) 1st Step: Preliminary examination

In the beginning, the following three locations (plans) were compared.

- **Plan A**: The same location of the DGRs (rehabilitation of DGRs)
- **Plan B**: Upstream of DGRs (new construction)
- **Plan C**: Downstream of DGRs (new construction)

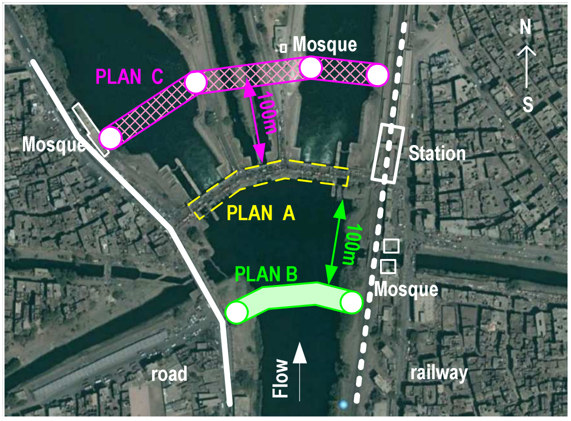


Figure 4-1.1 Preliminary layout of NDGRs' axis

As the result of preliminary examination, NDRGs shall be constructed downstream of DGRs, which means that Plan C will be adopted.

2) 2nd Step: Detailed examination

In the detailed examination, layouts of the regulator axis were selected taking the following points into consideration:

- To secure enough space for the construction yard with due consideration given to the condition of site,
- To secure easy maintenance and effective operations as proper water diversion works (regulators),
- To mitigate negative impacts of the construction of NDGRs on the DGRs,
- To select locations for the new Sahelyia and Abo Gabal regulators that will solve the sedimentation issue.

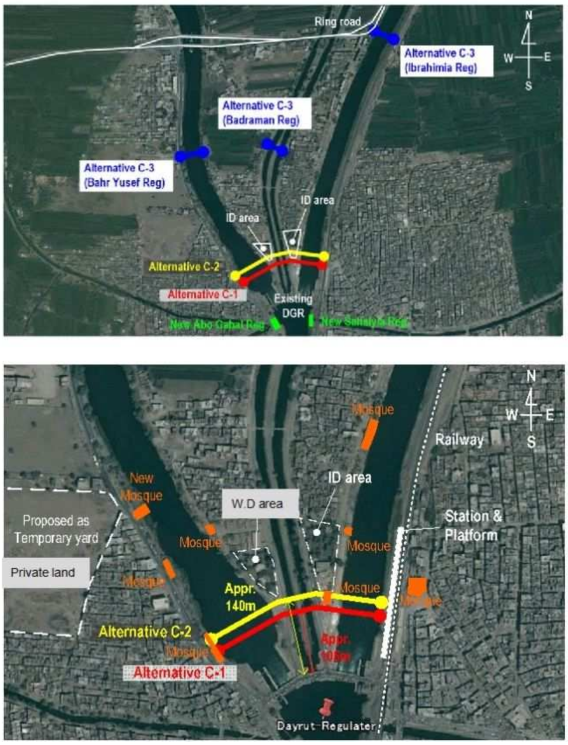


Figure 4-1.2 Layout of NDGRs' axis in the detailed examination stage

In the context of the above matters, the following three locations (plans) were compared.

Plan C-1: This layout is approximately 100m downstream of DGRs, and the new layout of Sahelyia and Abo Gabal regulators is in front of each of the existing regulators.

Plan C-2: This layout is approximately 140m downstream of DGRs, and the new layout of Sahelyia and Abo Gabal regulators is in front of each of the existing regulators.

Plan C-3: The layouts of NDGRs are scattered. The Bahr Yusef and Badraman regulators are approximately 600m downstream of DGRs, and Ibrahimia regulator is approximately 1,000m downstream of DGRs. The new layout of Sahelyia and Abo Gabal regulators is in front of each of the existing regulators.

The assessment symbols are as follows:

●: advantage

×: disadvantage.

Plan C-1: 100m downstream of DGRs

● This plan has the advantage of having proper distribution functions as an integrated regulator, as well as the stability of the structure, and ease of construction.

× The temporary cofferdam touches DGRs, so the apron and navigation lock on DGRs need to be partially demolished before the construction of NDGRs.

Plan C-2: 140m downstream of DGRs (adopted)

● This plan has the advantage of having proper distribution functions as an integrated regulator, as well as structural stability, and ease of construction (same as Plan C-1).

● Additionally, the temporary cofferdam does not reach to the DGRs in order to construct the NDGRs. This plan preserves the DGRs as historical monuments.

Plan C-3: 600-1,000m downstream of DGRs

● Set further downstream from Plan C-2, this plan is 600m-1,000m downstream of DGRs and avoids densely-populated area.

× The maintenance bridge on each regulator is not continuous. Therefore, it takes extra time to reach each regulator, making it difficult to maintain NDGRs properly.

× Gate operation could be a difficult to regulate discharge as new regulators are substantially away from diversion place of DGRs. Discharge will therefore not be controlled by regulator gates of NDGRs, but by the dischargeable capacity of DGRs vents. This causes unexpected backwater to move upstream of NDGRs.

× The low elevation 140m ahead of the downstream requires the building of an embankment along the canal from the NDGRs to DGRs against the raised water level, because of the expansion of the backwater area. This would increase costs and affect the surrounding area through possible seepage.

3) Conclusion of F/S stage

As a result of detailed examination, it was decided that NDGRs would be build 140m downstream of DGRs as confirmed by TAC on 30th March, 2010, thereby adopting Plan C-2.

(2) Request for supplemental examination at the Basic Design stage

During the study on the basic design stage, the Egyptian side requested that impacts on existing DGRs in the construction stage be avoided, and suggested a plan in which the wire axis be set 150m downstream from the existing DGRs. The D/D consultants agreed to conduct a supplemental examination of the plan above and compare between the 140m and 150m plans.

4-2 Location of regulator axis

As the result of these deliberations, NDGRs will be located 140m downstream of the existing DGRs, and Sahelyia and Abo Gabal regulators will be located in front of the existing ones. This is in conformity with the decision at F/S stage approved at the 6th TAC meeting.

(1) Effect on existing DGRs

Double sheet piles for the cofferdam could mitigate the negative impacts to the DGR foundations in the construction stage. The embedded length of this sheet pile shall be secured to the necessary length to avoid the influence of piping and seepage underneath the DGRs onto the construction yard. The following formula from the Japanese design criteria will be used for the examination to mitigate the negative impacts.

$F = L1 / h1$ and $L2 / h2 \geqq Fs$

where,

L1 and L2: Creep (seepage) length

h1: Water depth

h2: Difference length between water level and level of construction yard

F: Safety factor

Fs: Required safety factor

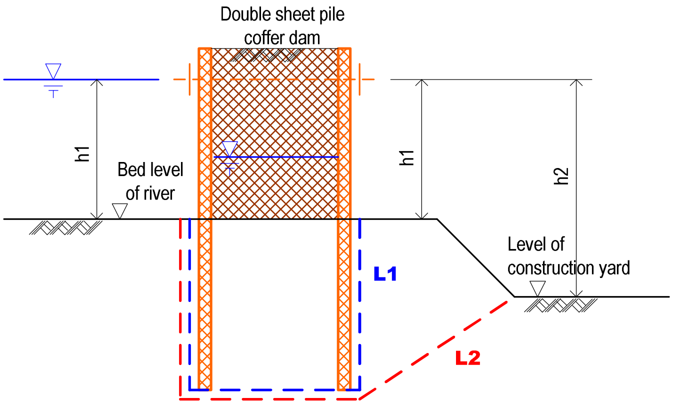


Figure 4-2.1 Schematic sketch for calculation

No negative impacts of piping and seepage were observed during construction in the four previous Japanese grant aid projects along the Bahr Yusef canal. The stability of the existing regulator was secure, including the exiting one located just beside the double sheet pile cofferdam.

Therefore, no negative impacts such as piping and seepage are expected. Monitoring instruments/devices that inspect the stability of DGRs, are expected to be installed at the construction stage.

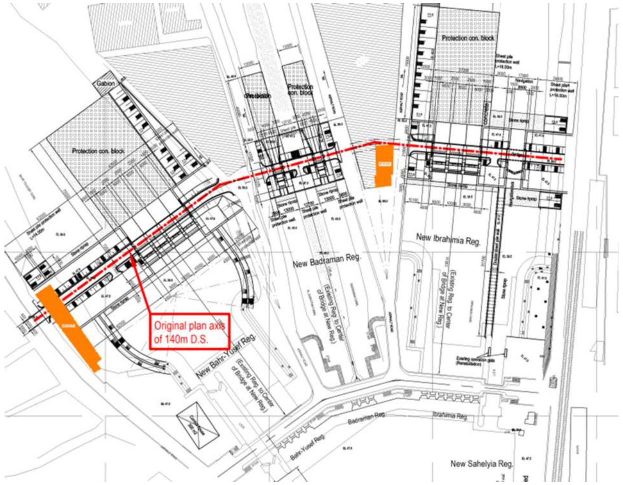
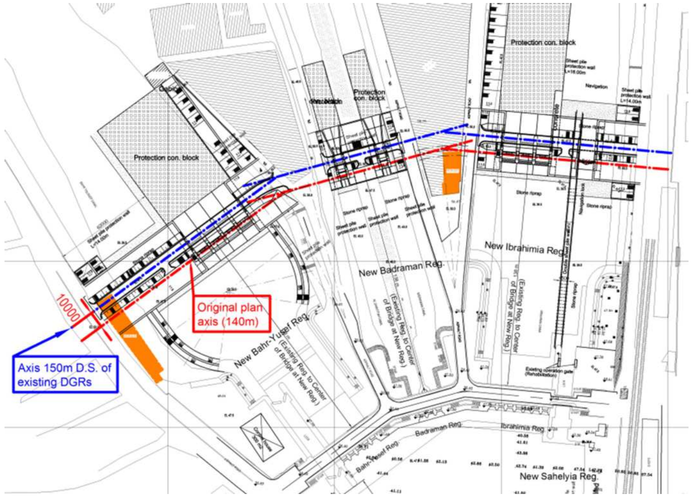
(2) Impact on groundwater

Comparing the impact on groundwater between 140m D/S which was applied in F/S stage (Plan 1) and 150m D/S which was suggested in B/D stage (Plan 1), it was expected that the Plan 1 has an advantage due to smaller upstream pooled area which makes smaller impact on the groundwater.

(3) Result

Following the evaluation, Table 4-2.1 shows the general advantage of 140m axis to 150m axis.

Table 4-2.1 Comparison of NDGRs' axis between 140m and 150m downstream of DGRs

Items	Plan 1 : NDGRs at 140m downstream of DGRs	Plan 2 : NDGRs at 150m downstream of DGRs
Figure of Layout	 Original plan axis of 140m D.S. Protection con. block Gabion New Badraman Reg. New Ibrahimia Reg. New Bahr-Yusef Reg. New Sahelyia Reg. Ibrahimia Reg. Badraman Reg. Bahr-Yusef Reg.	 Original plan axis (140m) Axis 150m D.S. of existing DGRs 10000 Protection con. block New Badraman Reg. New Ibrahimia Reg. New Bahr-Yusef Reg. New Sahelyia Reg. Ibrahimia Reg. Badraman Reg. Bahr-Yusef Reg.
1. Impact of hydraulic features on DRGs	- Flow velocity upstream of NDGRs is reduced and smaller than that downstream of NDGRs, because of the development of the basin (impounded) area and generally stable water level upstream. Therefore, DGRs would not be affected by the high flow velocity. **Point: 2**	- Same as plan 1 **Point: 2**
2. Impact of geological features on groundwater	- Basin area upstream of NDGRs will affect the vicinity of NDGRs. According to simple analysis, the affected area is assumed as per "Attached comparison tables." - Smaller negative impact compared to Plan2 dues to smaller upstream pooled aera. **Point: 2**	- Basin area upstream of NDGRs will affect to the vicinity of NDGRs. According to the simple analysis, the affected area is assumed as per "Attached comparison tables." - Comparing between plan 1 and plan 2, show that the area affected by seepage in plan 2 is larger than that in plan 1. **Point: 1**
3. Impact on construction plan	- Protection works such as sheet-piles for seepage shall be measured. **Point: 2**	- Protection works such as sheet-piles for seepage shall be measured. - The necessary area for the protection works is larger than that in plan 1, because of the larger area affected by seepage in plan 2. Accordingly, protection works in plan 2 shall be at least 20m longer (10m x 2) than those in plan 1, therefore increasing construction costs. **Point: 1**

4. Impact on vicinity	- Two mosques shall be relocated to other areas to avoid impact by construction work. - The residential area downstream of the right bank of the Bahr Yusef canal, which is close to the Irrigation Department, may be affected by the temporary cofferdam. **Point: 1**	- Two mosques shall be relocated to other areas to avoid impact by construction work. - The residential area downstream of the right bank of the Bahr Yusef canal, which is close to the Irrigation Department, may be affected by the temporary cofferdam. However, as the affected area is larger than that in plan 1, therefore increasing the construction costs. **Point: 0**
5. Comprehensive evaluation	**Total point : 7** **Recommended** - The DGRs building according to both plans yields similar hydraulic impact, but the lesser effect of seepage in plan 1 gives it an advantage over plan 2, as does the lower construction cost for protection works. **Recommending the adoption of plan 1 for construction works 140m downstream of DGRs**	**Total point : 4** **Not Recommended** - The DGRs building according to both plans yields similar hydraulic impact, but the greater effect of seepage in plan 2 puts it at a disadvantage versus plan 1, as do the higher construction cost for protection works.

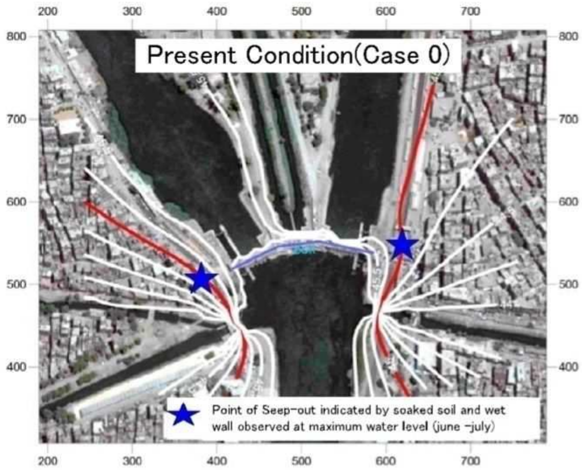
1) Maximum point shall be 2 points in conformity with the number of plans.

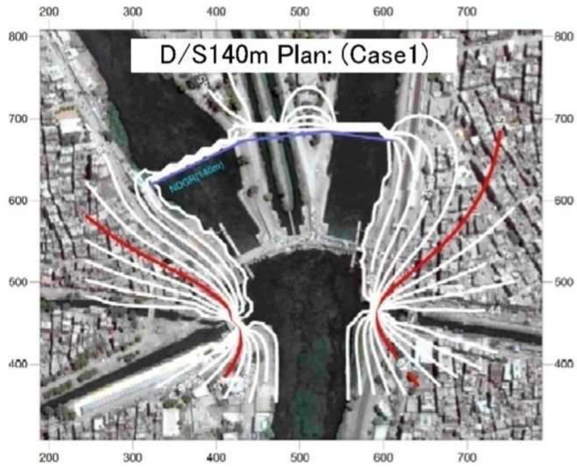
2) No item shall be given more weight in order to evaluate fairly.

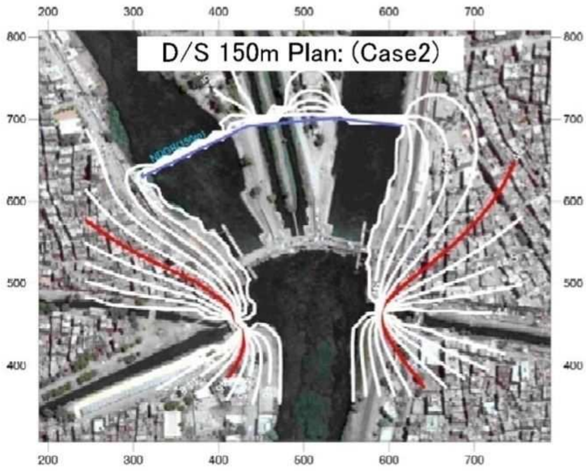
- **Attached comparison tables**

Estimated Water Head (ELm)

(at present condition, after construction of D/S140m & 150m Plan)

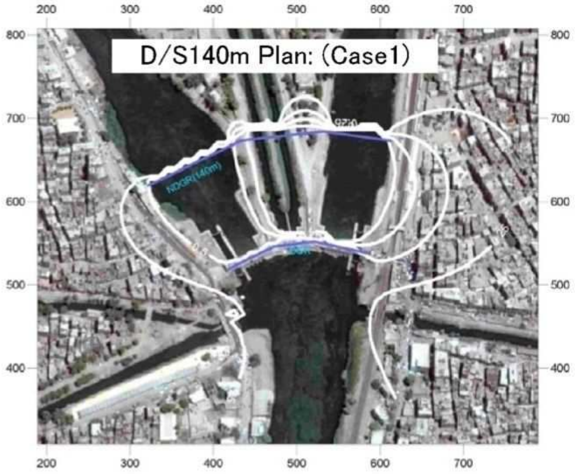

Present Condition(Case 0)
Point of Seep-out indicated by soaked soil and wet wall observed at maximum water level (june -july)
200
300
400
500
600
700
800
700
600
500
400

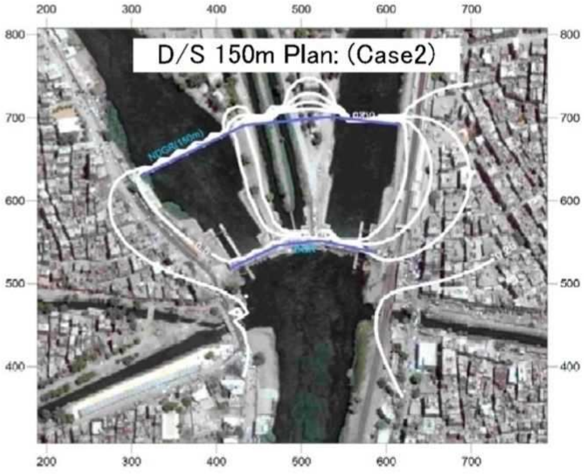


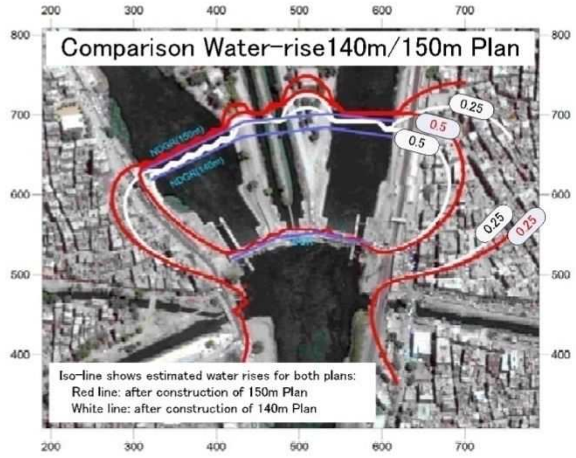


Estimated Water Rise (m)

(after construction of D/S 140m & 150m Plan and thier Comparison)






Comparison Water-rise140m/150m Plan
NDGR(150m)
NDGR(140m)
0.25
0.5
0.5
0.25
0.25
Iso-line shows estimated water rises for both plans:
Red line: after construction of 150m Plan
White line: after construction of 140m Plan
200
300
400
500
600
700
800
700
600
500
400

5. Weir Type

5-1 Determining weir type

Weirs are either of the fixed type constructed on the rock layer, or the floating type constructed on the permeable layer. In the project, since the geological conditions are mainly sand and clay, the floating type weirs should be used in the NDGRs.

In the design of floating type, it is important to maintain the stability of the foundation, and avoid the rising of piping and scouring at the canal bed.

5-2 Study of gate and hoist type

5-2-1 Size of target gates

Based on the results of hydraulic and structural design of weir body, the target gate facility sizes are as follows.

There are eight gates for the large scale regulators (Bahr Yusef and Ibrahimia regulators) and eleven for the small scale regulators (Sahelyia, Badraman and Abo Gabal regulators).

Table 5-2.1 Size of gates for the two large scale regulators

Name of regulator	**Bahr Yusef**	**Ibrahimia**
Clear span	6.00m	6.00m
Gate height	6.55m	6.55m
Area of a leaf	39.3m^2	39.3m^2
Gate sill elevation	EL40.00m	EL40.00m
Gate crest elevation	EL46.55m	EL46.55m
Number of gate	4	4

Table 5-2.2 Size of gates for the three small scale regulators

Name of regulator	Sahelyia	Badraman		Abo Gabal	
Name of canal	Sahelyia	Diroutiah	Badraman	Irad Delgaw	Abo Gabal
Clear span	2.00m	2.00m	2.00m	2.00m	2.00m
Gate height	3.55m	2.35m	2.65m	2.95m	2.95m
Area of a leaf	7.10m^2	4.70m^2	5.30m^2	5.90m^2	5.90m^2
Gate sill elevation	EL43.00m	EL44.20m	EL43.90m	EL43.60m	EL43.60m
Gate crest elevation	EL46.55m	EL46.55m	EL46.55m	EL46.55m	EL46.55m
Number of gate	2	3	2	2	2

5-2-2 Large scale regulators

(1) Type of gate structure

Bahr Yusef and Ibrahimia regulator are the important facilities which control about 90% of the total discharge from all the DGRs though gate functions. Therefore, the appropriate selection of gate type significantly impacts the functioning of all the regulators and their future maintenance. Generally, gate types are classified by: the movement of the gate, the structure of gate leaf, the form of discharge, the type of hoist, etc. The fixed wheel vertical lift gate is the most suitable for both regulators in terms of regulator scale, Japanese and Egyptian experience, reliability, etc.

Although a radial gate was selected for the Naga Hammadi Barrage (clear span 17m x height 13.5m x 7 gates) and Assiut Barrage (clear span 17m x height 9.6m x 8 gates) which are now under construction, they are constructed in the Nile River and their scale and functions are different from those of DGR. A fixed wheel gate was selected for the Ibrahimia head regulator (clear span 5m x height 5m x 9 gates) which was recently renovated.

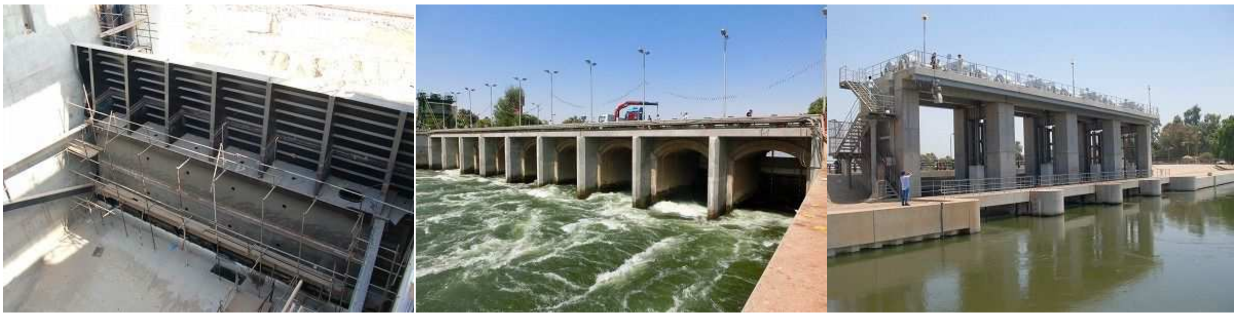


Figure 5-2.1 Examples of gate facilities in Egypt

From left: Assiut Barrage (Radial gate), Ibrahimia head regulator (fixed wheel gate), El Dahab regulator (overflow double leaf gate)

The four regulators constructed by Japanese grant aid project along the Bahr Yusef canal, have overflow double leaf gates. These consist of two leaves and can easily control discharge and water levels. This type of gate was expected to be selected for use on the Bahr Yusef and Ibrahimia regulators, as they utilize Japanese technology and comply with STEP.

The discharge flow features of the double leaf gate were compared to those of single leaf gate, under the design conditions of discharge and canal water level. Studies clarified that control by overflow or underflow volume was greater using double leaves, as was accuracy and stable water diversion. The decision to adopt a double leaf overflow gate was made in the 10th TAC meeting held on January 31and February 7, 2016.

(2) Hoist type

Wire-rope winding type hoisting equipment, widely used in Japan was used in the four regulators constructed in the Bahr Yusef canal by the Japanese grant aid project. On the other hand, the hydraulic cylinder type has become popular in Egypt and was used in projects like the Ibrahimia head regulators, the Naga Hammadi Barrage, and the new Assiut Barrage.

Therefore, three types of hoists can be used with a double leaf gate, (1) electric wire rope winding type, (2) hydraulic cylinder direct attached type, and (3) hydraulic cylinder wire rope winding type. Upon comparison, the hydraulic cylinder direct attached type was found to be the most suitable, especially for future ease of maintenance works and landscape, and was therefore selected for use in the 10th TAC meeting.

Table 5-2.3 Comparison of discharge control between single and double leaf gate (1/2)

(1/2)

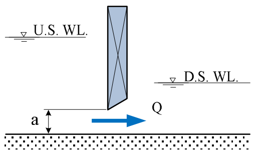
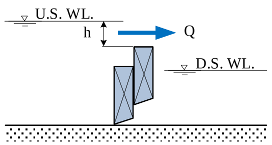
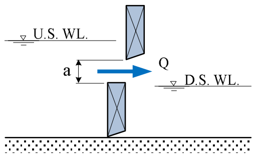
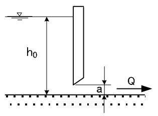
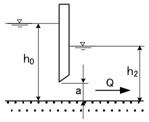
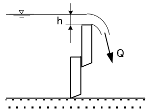
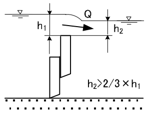
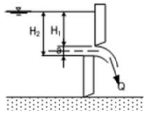
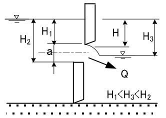
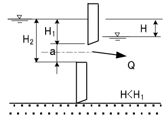
Description		Single Leaf-gate		Double Leaf-gate				
		(Under-flow control)		(Over-flow control)		(Orifice-flow control)		
Schematic drawing								
Structural feature		1)The gate consists of one gate leaf, and it has skin plate which is supported by steel beams to resist the water pressure. 2)Thickness of gate leaf is constant from the bottom to the top, arrangement of main girder is variable.		1)The gate consists of two gate leaves, a lower gate and an upper gate. Each gate leaf has skin plate which is supported by steel beams to resist the water pressure. 2)Generally, the water pressure acting on the upper leaf is smaller than the lower gate, therefore, the thickness of the upper gate is thinner than that of the lower gate. 3)The height of the upper gate can be designed within a half of water head.		1)The gate consists of two gate leaves, a lower gate and an upper gate. Each gate leaf has skin plate which is supported by steel beams to resist the water pressure. 2)Generally, The water pressure acting on the upper leaf is smaller than the lower gate, therefore, the thickness of the upper gate is thinner than that of the lower gate.		
Hydraulic feature	**General**	1)Form of flow is classified in free flow and submerged flow depending on the water level. 2)Fluctuation of discharge for the change of gate openings is larger than that of over flow type. The ability to control discharge accurately is inferior to the over-flow control. 3)High velocity of flow usually occurs and this might cause abrasion of apron concrete .		1)Form of flow is classified in complete overflow and submerged overflow depending on the water level and opening. 2)Fluctuation of discharge for the change of gate openings is smaller than that of under flow type. High accurate control of discharge is possible. 3)Discharge from under flow is also possible according to the purpose.		1)Fluctuation of discharge for the change of gate openings is larger than that of over flow type. 2)Discharge from under flow is also possible according to the purpose.		
	Form of flow	**Free outflow**	**Submerged flow**	**Complete overflow**	**Submerged overflow**	**Free orifice flow**	**Incomplete submerged orifice flow**	**Complete submerged orifice flow**
								
		$Q=CaB(2gh_0)^{1/2}$ Q:Discharge (m^3/s) C:Coefficient of discharge a:Opening (m) B:Span length (m) h_0:Upstream water depth (m)	**$Q=C_1aB(2gh_0)^{1/2}$** Q:Discharge (m^3/s) C_1:Coefficient of discharge a:Opening (m) B:Span length (m) h_0:Upstream water depth (m)	**$Q=CBh^{3/2}$** Q:Discharge (m^3/s) C:Coefficient of discharge B:Span length (m) h:Overflow depth (m)	**$Q=CBh_1(h_1-h_2)^{1/2}$** Q:Discharge (m^3/s) C:Coefficient of discharge B:Span length (m) h_1, h_2: cf. fig. (m)	**$Q=2/3CB(2g)^{1/2}(H_2^{3/2}-H_1^{3/2})$** Q:Discharge (m^3/s) C:Coefficient of discharge B:Span length (m) H_1, H_2: cf. fig. (m)	**$Q=CaB(2gH)^{1/2}$** Q:Discharge (m^3/s) C:Coefficient of discharge a:Opening (m) B:Span length (m) H:cf. fig. (m)	**$Q=CaB(2gH)^{1/2}$** Q:Discharge (m^3/s) C:Coefficient of discharge a:Opening (m) B:Span length (m) H:Water level difference (m)
		･Discharge volume Q is the function of h_0 and a. ･Minimum clearance for the opening (a) is 0.10m owing to self-exiting vibration (It occurs under the condition in smaller clearance than 0.10m).	･It is hard for the stable discharge control because C_1 is affected by three variables (h_1, h_2 and a). ･It is also unclear in the demarcation between free and submerged outflow.	･Discharge volume Q is the function of only one variable, overflow depth h; therefore, discharge control is the simplest to operate because it is hydraulically superior condition. ･Besides, this method has the best accuracy in discharge control.	･Discharge volume Q is the function of h_1 and h_2. ･It is clear in the demarcation between complete overflow and submerged overflow.	･Discharge volume Q is the function of H_1 and H_2 (or H_1 and a). ･Minimum clearance for gate opening a is 0.10m owing to self-exiting vibration (It occurs under the condition in smaller clearance than 0.10m).	･Discharge volume Q is the function of H (water depth from the downstream vena contracta and a). ･It is irrational to calculate Q around the boundary between complete and imcomplete submerged flow owing to the inconsistency in those equations .	･Discharge volume Q is the function of H (difference in water level between H_1 and H_2) and a, which is relatively stable in this condition.

Table 5-2.4 Comparison of discharge control between single and double leaf gate (2/2)

(2/2)

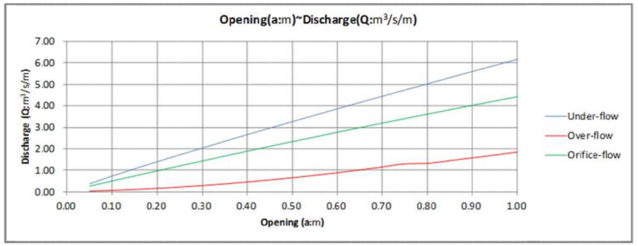
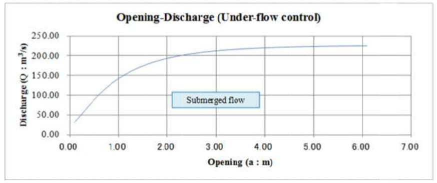
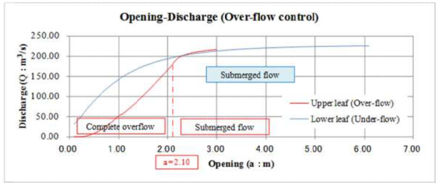
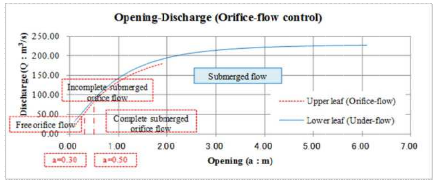
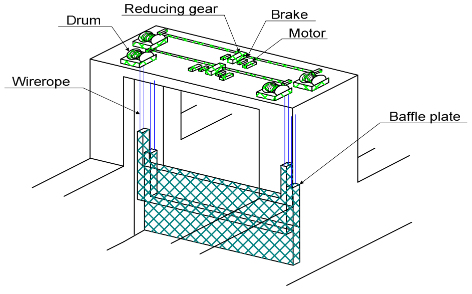
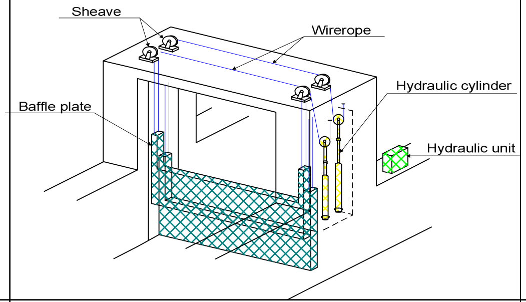
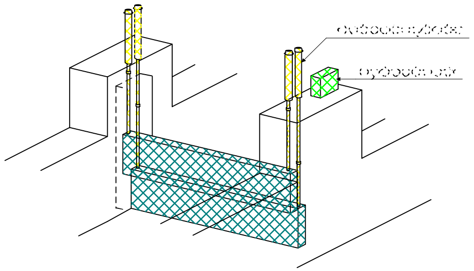
Description		Single Leaf-gate	Double Leaf-gate	
		(Under-flow control)	(Over-flow control)	(Orifice-flow control)
Hydraulic feature	General verification results of hydraulic consideration	General verification results of hydraulic consideration in unit gate length among three discharge control methods which are under-flow control (free outflow), over-flow control (complete overflow), and orifice-flow control (free orifice flow). This figure also indicates that over-flow control (complete overflow) has smallest discharge volume change, in response to the change in gate opening, which means the over-flow control is superior method to the others in discharge volume control (Under-flow control (free outflow) is the has the biggest discharge volume change among three methods).		
	Verification results of hydraulic consideration in the case of the Bahr-Yusef Reg.			
		･It is not subject to gate opening and is always submerged flow owing to high downstream water level. ･Minimum discharge volume (at minimum gate clearance, 0.10m) is about 10m^3/s. ･When the discharge volume is more than 150m^3/s, difference in discharge volume by gate opening is stable.	･Boundary between complete overflow and submerged flow is when the opening is 2.10m. ･Under the condition that the discharge volume is less than 110m^3/s, over-flow is superior to under-flow in accurate discharge control. ･Discharge volume control with highest accuracy can be possible when over-flow control by upper leaf and under-flow control by lower leaf are properly applied depending on gate opening.	･Orifice flow control has equivalent property to under-flow control ･Under the condition that opening a is more than 1.90m, the solution in discharge volume is irrational. ･This method has unstable water state in small opening condition. ･Considering the conditions above, there is no merit to apply this method.
Hoisting equipment		1)Both hydraulic cylinder type and wire rope winding type are applicable.	1)Both hydraulic cylinder type and wire rope winding type are applicable. 2)In the case that hook type of gate is installed for upper leaf and combined with lower gate, one set of hoisting device is used. 3)Installing two sets of hoisting equipment can make gateposts shorter by shortening apparent gates height when they are fully open.	1)Both hydraulic cylinder type and wire rope winding type are applicable. 2)Two sets of hoisting devices are necessary to operate each leaf. 3)Installing two sets of hoisting equipment can make gateposts shorter by shortening apparent gates height when they are fully open.
Maintenance		1)Periodical inspection and maintenance are possible by lifting up the gates.	1)Periodical inspection and maintenance are possible by lifting up the gates. 2)The number of items to be inspected is larger than that of single leaf type.	1)Periodical inspection and maintenance are possible by lifting up the gates. 2)The number of items to be inspected is larger than that of single leaf type.
Comprehensive Evaluation		**Accurate discharge control and stable diversion to the seven directions of canals are the major required function of NDGRs.** **This type is inferior to over-flow control in this point.**	**Accurate discharge control and stable diversion to the seven directions of canals are the major required function of NDGRs.** **This type is superior to other types in this point.**	**Accurate discharge control and stable diversion to the seven directions of canals are the major required function of NDGRs.** **This type is inferior to over-flow control in this point.**
		△	◎	×

Table 5-2.5 Comparison of hoist types for the large scale regulators

		Wire rope winding type (Electric motor)		Oil-hydraulic cylinder			
				Wire rope winding type		Direct attached type	
Schematic drawing		 Drum Reducing gear Brake Motor Wirerope Baffle plate		 Sheave Wirerope Baffle plate Hydraulic cylinder Hydraulic unit			
General characteristics		1)This type is widely used for any lifting heights and loads except a case that requires closing pressure. 2)There are several sub-styles with different combinations of wiring and number of drums. 3)In case double leaf gate, wiring and placement of hoisting devices become complicated. 4)It is impossible to push down the gate leaf by the force of hoist.		1)The gate leaf is operated by hydraulic cylinder through wirerope. 2)It is possible to install the hydraulic cylinder in a remote place from the gate leaf. 3)The structure of hoisting device is usually complicated. 4)It is better not use this type for a gate of large lifting height and large load because of difficulties in terms of structure. 5)It is impossible to push down the gate leaf by the force of hoist.		1)A hydraulic cylinder rod is attached directly to the leaf and the leaf is operated by pressurized oil. 2)This type is widely used for high pressure gates. 3)It is advantageous when the opening of the gate leaf must be strictly adjusted or when the hoisting device should be installed in a narrow space. 4)Not only pulling up the gate leaf but also pushing down it is possible by the force of hoist.	
Main components of the facility	Gate leaf	Gate leaf (Rolled steel) Roller Watertight rubber		Gate leaf (Rolled steel) Roller Watertight rubber		Gate leaf (Rolled steel) Roller Watertight rubber	
	Guide frame (Stainless steel)	Guide frame (Stainless steel)		Guide frame (Stainless steel)		Guide frame (Stainless steel)	
	Hoisting device	Sheave Brake Wire rope Motor Bearing of motor Clutch Reduction gear		Sheave Wire rope Hydraulic pump Valve Bearing of motor Cylinder (SUS) Cylinder packing		Hydraulic pump Valve Bearing of motor Cylinder (SUS) Cylinder packing	
Functional characteristics	Civil structure	Since baffle plate is required at the both edges of the gate leaf to protect wire rope and to avoid vibration of it, the height of pier becomes higher.	+	Since baffle plate is required at the both edges of the gate leaf to protect wire rope and to avoid vibration of it, the height of pier becomes higher.	+	Baffle plate is not required at the both edges of the gate leaf because the cylinder rods are made of stainless steel and have high stiffness. For this reason, the height of pier can be lowered and the structure is relatively simple.	++
	Discharge control	When double leaf gate type is applied, overflow control as well as underflow control is possible.	+	When double leaf gate type is applied, overflow control as well as underflow control is possible.	+	When double leaf gate type is applied, overflow control as well as underflow control is possible.	+
	Arrangement and space for hoist	Wide space is necessary to install the equipment.	+	There is a flexibility of placement.	++	Since the number of hoisting parts is few, necessary space for installation is small.	+++
	Maintenance	1)Necessary inspection and maintenance items are largest.	+	1)Necessary inspection and maintenance items are larger. 2)Oil leakage must be monitored and avoided. Maintenance of hydraulic oil as well as packing is very important.	+	1)Compared with mechanical type, necessary inspection items are small. 2)Oil leakage must be monitored and avoided. Maintenance of hydraulic oil as well as packing is very important.	+
	Landscape	High piers and complicated hoisting devices affect landscape.	+	The height of piers is higher than that of hydraulic cylinder type.	++	The height of pier is shortest and hoisting devices are compact.	++
Approximate cost of hoisting device (Gate size;B=8m x H=6.55m)		2.1 Million USD/set	+	1.8 Million USD/set	++	1.5 Million USD/set	+++
Recommendation						Recommended plan by JICA survey team	

Note: +++:Excellent ++:Good +:Average

5-2-3 Small scale regulators

(1) Structural type of gate

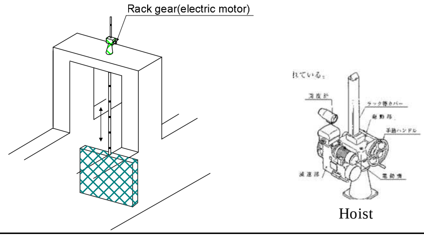
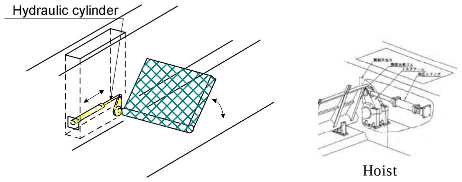
Badraman, Sahelyia, and Abo Gabal regulators divert into two canals except for the Sahelyia regulator. Considering their design discharge, gate height and width are 10m^3/s, 3.0m and 2.0 m respectively, those regulators are classified as a small gate group with less than 10m^2 of gate leaf area. The type of large gate is mainly the slide gate and the bottom hinge flap gate. The former's gate leaf moves up and down, and the latter's is moved by rotating on its hinge

The double leaf gate could be used with the small regulator, but the lower accuracy of operation as a result of the small discharge excludes it as a suitable choice.

After considering the merits and demerits of both gates as shown in Table 5-2.6, the slide type gate was approved at the 11th TAC based on cost and ease of maintenance. The hinge flap gate type was better at operating the water levels and discharge volume, but was not recommended because it had not been used in Egypt before.

As for the number of spindles; the two spindles type was approved at the 22nd TAC meeting.

Table 5-2.6 Comparison table of gate types for the small scale regulators

Gate type	Slide gate	Bottom hinge flap gate
Hoist type	Rack gear type/Screw spindle type	Hydraulic cylinder type
Schematic drawing		
General characteristics	1)Screw spindle or rack gear which are attached to the leaf and the leaf are operated mechanically. 2)This type is not appropriate for large vent or high lift gate from view points of structural stiffness and mechanical effectivity.	1)The gate leaf bottom is fixed to the canal bed by means of a hinge. 2)Both sides (or one side)of a hinge pin at the bottom of the gate leaf are supported by torque. The driving force is transmitted through a rocker arm installed in the pier by an oil hydraulic cylinder.
Discharge control	Underflow only	Overflow only More accurate discharge control is possible.
Civil structure	1)Since the gate leaf is lifted up vertically, high pier and slab to install the hoisting devices are necessary. 2)High piers and hoist will affect landscape a little.	1)This type requires shorter piers and matches with current landscape.
Maintenance	1)Maintenance works are easier than overflow gate because the gate leaf can be fully lifted up. 2Hoisting device is standardized and unitized in Japan. It is difficult to inspect inside of the device. 3)Lubrication to the movable parts is the main maintenance work. 4)It is difficult to release the floating debris by gate operation.	1)Oil leakage must be monitored and avoided. 2)Since the gate leaf is always submerged, stop logs are required to inspect the gate leaf and seal parts. 3)Floating debris can be removed easily by gate operation. 4)Prevention of sediment flowing into canal is possible.
Rough cost ratio	1.0	2.0
Total gate leaf area	51m^2	61m^2
Conclusion	Recommended	Discharge controllability is superior, but this type is not common in Egypt and costly as well.

(2) Hoist type

The hoist type of slide gate is best suited for the rack gear type as it is simply built and therefore easier to maintain. Models that close by force or close by self-weight are also available. After considering the appropriate number of shafts connecting to the gate leaf with regard to the clear span width or horizontal to vertical ratio, the Egyptian government and the Design WG found two shafts were best at promoting high stability during operation.

Table 5-2.7 Selection of hoist type

Gate type	Scale of gate	Hoist type	
		Rack type	Wire rope winch type
Wheel gate	Small scale	○	△
	Medium scale	○	○
	Large scale	△	○
Slide gate		○	×

Note: ○ : Appropriate to use
× : Inappropriate to use
△ : Appropriate to use depending on occasions

Source: *Guidelines on sluice gates* (Japanese)

6. Width and Number of Vents

Discharge volume of NDGRs determines vent width and number. The Bahr Yusef and Ibrahimia regulators are defined as the large regulars and the Sahelyia, Badraman, and Abo Gabal regulators are defined as the small regulars.

6-1 Two large scale regulators

(1) Procedure of study

A comparative study on the various combinations of width to number of vents was carried out as follows.

a) Assumptions on width and number of vents

The width or the clear span length of vents for large regulators constructed on the main canal is generally 4-6m according to the Egyptian textbook, *Part No. 2 Design of Hydraulic Structures, Spillways, Regulators and Barrages*. A width of 8m was selected based on a feasibility study as well as the specifications of existing regulators along the Bahr Yusef canal like El Dahab regulator which was constructed by a Japanese grant aid projects. Therefore vents 4,5,6,7 and 8m in width were considered, and the number of vents adjusted accordingly. Given the importance of the Bahr Yusef and Ibrahimia canals, and the importance of distributing risk in the event that one of the gates fails to operate, as well as a discussion between the Egyptian government and the survey team at the 10th TAC meeting, the minimum number of vents was set at three.

b) Hydraulic analysis by non-uniform flow calculation

The capacity of assumed flow section against the design maximum flow discharge was verified by non-uniform calculations on the condition that all the gates of new regulators are fully opened. The starting water level just downstream of the new regulators was the maximum water level which the Water Distribution Directorate in RGBS was able to provide.

Table 6-1.1 Conditions of hydraulic calculation

	Bahr Yusef regulators	Ibrahimia regulators
Design discharge	$227m^3/s$	$186m^3/s$
Water level at the starting point	45.82m	45.13m
Design upstream water level	46.30m	46.30m

c) Hydraulic judgment

If the calculated water level upstream of existing regulators is below the design intake water level (46.30m), the cross section of the new regulators is assumed to be enough to discharge the design volume. In addition, some relevant conditions in the Egyptian code needed to be met. The conditions to be examined are as follows.

- Check 1 : Capacity of design discharge flow

  Calculated water level at the upstream of existing regulators≤WL.46.30m

- Check 2 : The maximum allowable velocity (Vr) through vents

  $2\ V_{DS} < Vr < 3\ V_{DS}$

  where, Vr: Velocity through vents (Vr =1.00-2.00 m/s)

V_{DS} : Velocity of channel downstream (m/s)

- Check 3 : Flow area

$(A_{DS} - Are) / A_{DS} \leq 40\%$

where, Are : Area of the water way through the openings (m^2)

A_{DS} : Area of the canal cross section downstream the structure (m^2)

- Check 4 : The maximum allowable heading-up

$$h = \frac{{V_{US}}^2}{2gC^2}\left(\left(\frac{A_{US}}{A_r}\right)^2 - 1\right) \leq 10\ cm$$

where, V_{US}: Velocity in channel without regulator (m/s)

A_{US}: Cross section area of flow without regulator (m^2)

Ar: Regulator vent area (m^2)

C: Factor depends on the vent width

g : Acceleration of gravity (=9.8m/s^2)

d) Comprehensive evaluation

A comprehensive evaluation of the combinations of the number and width of vents which meet the aforementioned hydraulic requirements was made to judge economy, discharge controllability, ease of maintenance, etc.

The costs of major civil works and gate facilities were roughly estimated as part of the economic evaluation.

(2) Result of study

For the comparative study, three combination were used, namely, 5m in width with 5 vents, 6m in width with 4 vents, and 8m in width with 3 vents, for both the Bahr Yusef and Ibrahimia regulators.

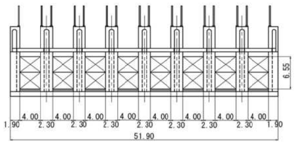
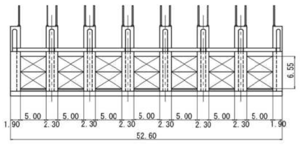
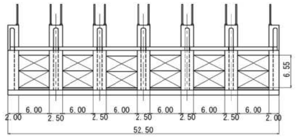
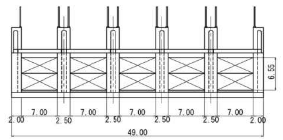
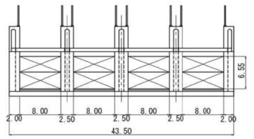
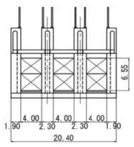
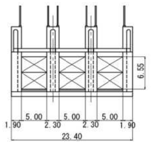
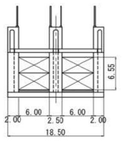
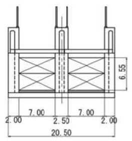
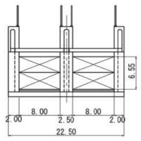
8m width was found to be the most economical and superior size in reducing construction area because the fewer number of piers results in the smallest total regulators width. However, the large regulators constructed on the main canals in Egypt, are within the 4-6m range, as described in the textbook. The exceptions to this rule are the four regulators constructed through the Japanese grant aid projects. The RGBS requested that what was successfully used in the past, in terms of operability and maintenance, be repeated. Consequently, the 6m wide vent, which is the second most economical choice, was selected for the Bahr Yusef and Ibrahimia regulators at the 10th TAC meeting.

Table 6-1.3 shows the results of an initial comparative study in which the Egyptian code is ignored to review feasibility. Table 6-1.4 shows the final version of the comparison which was approved by TAC in discussions between the survey team and the Egyptian government. Table 6-1.2 shows the design of vents on the large regulator.

Table 6-1.2 Design of vents on the large regulators

	New Bahr Yusef	New Ibrahimia
Vent width	6.00m	6.00m
No. of vents	4 vents	4 vents
Sill level	EL.40.00m	EL.40.00m

Table 6-1.3 Number and width of vents for the large scale regulators (initial results)

Width of vent(m)			4.00		5.00		6.00		7.00		8.00	
Total gate height(m)			6.55		6.55		6.55		6.55		6.55	
Bahr Yusef Regulator	Hydraulic calculation	Number of vent	7	8	6	7	5	6	4	5	3	4
		U.S.WL. (m)	46.32	46.30	46.31	46.30	46.31	46.29	46.32	46.30	46.35	46.30
		Judgement(≤46.30m)	Not available	Available	Not available	Available	Not available	Available	Not available	Available	Not available	Available
	Schematic drawing											
	Total width (m)		51.90		52.60		52.50		49.00		43.50	
Ibrahimia Regulator	Hydraulic calculation	Number of vent	2	3	2	3	2	3	2	3	2	3
		Flow velocity(m/s)	4.01	2.67	3.21	2.14	2.67	1.78	2.29	1.52	2.00	1.34
		Judgement(≤3.0m/s)	Not available	Available	Not available	Available	Available	Available	Available	Available	Available	Available
	Schematic drawing											
	Total width (m)		20.40		23.40		18.50		20.50		22.50	
Discharge controllability			**Low** Discharge rate per gate opening is so small that operation of gate becomes complicated.		→						**High** Discharge rate per gate opening is so large that operation of gate becomes easy.	
Easiness of maintenance works			**Low** Inspection and maintenance items are larger.		→						**High** Inspection and maintenance items are smaller.	
Easiness of construction (*1)			**Low** Switching of cofferdam is required and construction period becomes longer.		→						**High** Switching of cofferdam is not required and construction period becomes shorter.	
Economy (*2)			**Low** The quantities of gate facilities and civil works are larger.		→						**High** The quantities of gate facilities and civil works are smaller.	
			Bahr Yusef	**Ibrahimia**	**Bahr Yusef**	**Ibrahimia**	**Bahr Yusef**	**Ibrahimia**	**Bahr Yusef**	**Ibrahimia**	**Bahr Yusef**	**Ibrahimia**
Concrete volume of main body(m^3)			11,600	4,700	11,200	5,200	11,000	4,100	9,900	4,400	8,600	4,600
Number of foundation piles			520	220	500	230	500	190	450	200	390	210
Total weight of gate facilities(ton)			570	220	580	250	550	190	490	200	420	210
Cost for major civil works(Million USD)			6.9	2.9	6.7	3.1	6.6	2.5	5.9	2.6	5.2	2.8
Cost of gate facilities(Million USD)			13.1	4.9	12.2	5.3	11	3.7	9.5	3.8	8.1	4.1
Total cost (Million USD)			20.0	7.8	18.9	8.4	17.6	6.2	15.4	6.4	13.3	6.9
			27.8		27.3		23.8		21.8		20.2	
(ratio)			(1.38)		(1.35)		(1.18)		(1.08)		(1.00)	
Recommendation											Recommended plan by JICA survey team	

Note:

*1: This item is the evaluation of Barh Yusef Regulator only. Regarding Ibrahimia Regulator, there is no wide difference.

*2: This is the comparison of the total cost.

Table 6-1.4 Number and width of vents for the large scale regulators (final results)

(a)Bahr Yusef Regulator (Design discharge = 227 m^3/s Maximum downstream water level= 45.82m)

Width of vent(m)		**5.00**	**6.00**	**8.00**	Remarks
Number of vents designed by Egyptian code		**5**	**4**	**3**	
Hydraulic check	Number of vents	**5**	**4**	**3**	
	Required Upstream WL. (m)	45.99 OK	46.00 OK	46.01 OK	≤Normal water level(=46.30m) (Inflow head loss coefficient=0.2)
Selected number of vent		**5**	**4**	**3**	Minimum number =3 vents
Total width including piers (m)		38.0	35.5	33.0	
Approx. Quantities	Concrete volume of main body(m^3)	8,200	7,500	6,600	
	Number of foundation piles	370	340	300	
	Bridge surface area(m^2)	380	355	330	RC bridge,Effective width=10m
	Total weight of gate facilities(ton)	432	392	353	Stoplogs (1set=2pairs)included
Cost	Major civil works(Million USD) (a)	5.2	4.7	4.2	Main body, foundation and bridge
	Gate facilities(Million USD) (b)	9.0	7.7	6.4	Manufacture and Installation,stoplogs included
	(a) + (b)	14.2	12.4	10.6	
	Ratio of cost	(1.15)	(1.00)	(0.85)	
Conclusion			**Selected**		

(b)Ibrahimia Regulator (Design discharge = 186 m^3/s Maximum downstream water level= 45.13m)

Width of vent(m)		**5.00**	**6.00**	**8.00**	Remarks
Number of vents designed by Egyptian code		**5**	**4**	**3**	
Hydraulic check	Number of vent	**5**	**4**	**3**	
	Required Upstream WL. (m)	45.22 OK	45.22 OK	45.22 OK	≤Normal water level(=46.30m) (Inflow head loss coefficient=0.2)
Selected number of vent		**5**	**4**	**3**	Minimum number =3 vents
Total width including piers (m)		38.0	35.5	33.0	
Approx. Quantities	Concrete volume of main body(m^3)	8,200	7,500	6,600	
	Number of foundation piles	370	340	300	
	Bridge surface area(m^2)	380	355	330	RC bridge,Effective width=10m
	Total weight of gate facilities(ton)	432	392	353	Stoplogs (1set=2pairs)included
Cost	Major civil works(Million USD) (a)	5.2	4.7	4.2	Main body, foundation and bridge
	Gate facilities(Million USD) (b)	9.0	7.7	6.4	Manufacture and Installation,stoplogs included
	(a) + (b)	14.2	12.4	10.6	
	Ratio of cost	(1.15)	(1.00)	(0.85)	
Conclusion			**Selected**		

Bahr Yusef + Ibrahimia (Million USD)	28.4	24.8	21.2	
(Ratio)	(1.15)	(1.00)	(0.85)	

6-2 Three small scale regulators

(1) Procedure of study

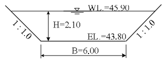
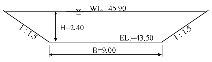
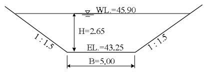
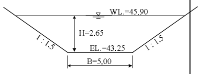
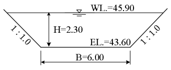
The small regulators are those in Badraman, Sahelyia, and Abo Gabal. Badraman and Abo Gabal regulators divert into two canals each. In these regulators, the results of reasonable combinations of vent width and numbers are shown in the ‘Result of study’ section below.

As for the Sahelyia and Abo Gabal regulators, the consideration of additional new hydraulic conditions was requested by the Egyptian side. The results are shown in the ‘Result of additional considerations’ section below.

1) Cross section and hydraulic conditions of downstream canals

Hydraulic parameters of connecting downstream canals such as flow area and velocity are obtained by uniform flow calculation based on the topographic survey result.

Table 6-2.1 Hydraulic conditions of downstream canals for the small scale regulators

Regulator Name		**New Sahelyia**	**New Badraman**		**New Abo Gabal**	
Canal Name		**Sahelyia**	**Diroutiah**	**Badraman**	**Irad Delgaw**	**Abo Gabal**
Design discharge	(m^3/s)	5.0	12.0	9.0	9.0	7.0
Water Level	(m)	45.90	45.90	45.90	45.90	45.90
Bed level	(m)	43.80	43.50	43.25	43.25	43.60
Water depth	(m)	2.10	2.40	2.65	2.65	2.30
Bed Width	(m)	6.00	9.00	5.00	5.00	6.00
Side slope 1:N		1.0	1.5	1.5	1.5	1.0
Flow area	(m^2)	17.01	30.24	23.78	23.78	19.09
Coefficient roughness		0.030	0.030	0.030	0.030	0.030
Canal bed slop		0.00005	0.00007	0.00007	0.00007	0.00007
Mean flow velocity	(m/s)	0.30	0.40	0.39	0.39	0.37
Design cross section		 WL.=45.90 H=2.10 EL.=43.80 1 : 1.0 1 : 1.0 B=6.00	 WL.=45.90 H=2.40 EL.=43.50 1 : 1.5 1 : 1.5 B=9.00	 WL.=45.90 H=2.65 EL.=43.25 1 : 1.5 1 : 1.5 B=5.00	 WL.=45.90 H=2.65 EL.=43.25 1 : 1.5 1 : 1.5 B=5.00	 WL.=45.90 H=2.30 EL.=43.60 1 : 1.0 1 : 1.0 B=6.00

2) Assumptions on width and number of vents

According to the textbook, *Part No. 2 Design of Hydraulic Structures, Spillways, Regulators and Barrages*, the width of vents for small scale regulators constructed in branch canals is almost less than 3m. Therefore, the examined width was within 3m in a 50cm unit. Given the importance of distributing risk in the event that one of the gates fails to operate, as well as a discussion between the RGBS and the survey team at the 11th TAC meeting, two vents were proposed and a comparative study was carried out to examine the proposal.

3) Hydraulic evaluation

In addition to the flow capacity, the following requirements stipulated in Egyptian code must be met.

- Check 1 : Capacity of design discharge flow
  Calculated water level at the upstream of new regulators≤WL.46.30m
- Check 2 : The maximum allowable velocity (Vr) through vents

$2\ V_{DS} < Vr < 3\ V_{DS}$

where, Vr : velocity through vents (Vr =1.00-1.50 m/s)

V_{DS} : Velocity of channel downstream (m/s)

- Check 3 : Number of vents and total length of regulator between abutments

  B2= (0.6to1.0)x B1

  Where, B1:Channel bed width (m), B2:Width between abutments of regulator (m)
- Check 4 : The maximum allowable heading-up

$$h = \frac{V_{US}^2}{2gC^2}\left(\left(\frac{A_{US}}{A_r}\right)^2 - 1\right) \le 10\ cm$$

or $$h = \alpha\beta \frac{V_{DS}^2}{2g}$$

Where, V_{US}: Velocity in channel without regulator (m/s)
A_{US}: Cross section area of flow without regulator (m^2)
Ar: Regulator vent area (m^2)
C:Factor depends on the vent width
α: Contraction ratio, β:Coefficient depending on a shape of pier
V_{DS}: Velocity of channel downstream (m/s)
g:Acceleration of gravity (=9.8m/s^2)

4) Comprehensive evaluation

A comprehensive evaluation of the combinations of the number and width of vents which meet the aforementioned hydraulic requirements was made to judge economy, discharge controllability, ease of maintenance, etc.

The costs of major civil works and gate facilities were roughly estimated as part of the economic evaluation.

(2) Result of study

A hydraulic examination and a comparison of rough cost estimates were carried out for the three following cases.

i) Case 1A: Width of vent is composed of 1.5m and 2.5m

ii) Case 1B: Width of vent is composed of 2.0m and 2.5m

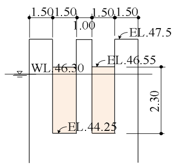
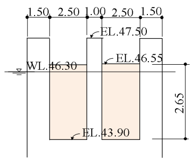
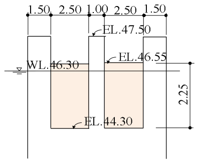
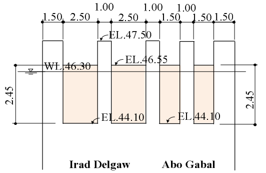
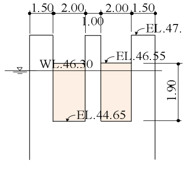
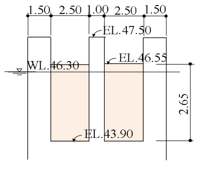
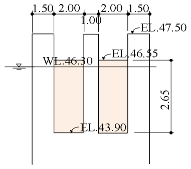
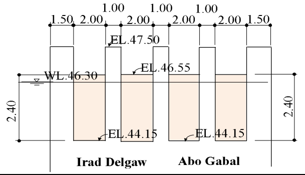
iii) Case 1C: Width of vent is 2.0m only

Table 6-2.2 summarizes the results for cases 1A, 1B, and 1C.

As there is no great difference in the construction costs in the three cases, case 1C was selected at the 12th TAC meeting, since it was the option where one stoplog was shared for all regulators during repair works.

Table 6-2.2 Comparison of width and number of vents for the small scale regulators (1/2)

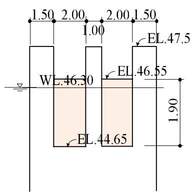
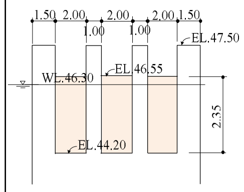
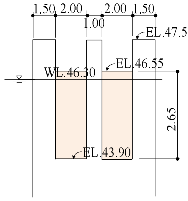
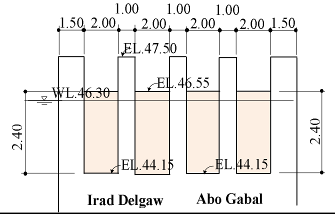
(1/2)

Regulator Name			New Sahelyia	New Badraman		New Abo Gabal		Rough cost ratio & Comments
Canal Name			Sahelyia	Diroutiah	Badraman	Irad Delgaw	Abo Gabal	
Design discharge (m^3/s)			**5.0**	**12.0**	**9.0**	**9.0**	**7.0**	
Design cross section of regulators	CASE1A: 2 different width (1.5m x 2.5m) Slide gate (underflow)	Width and number of vents	**1.50m × 2Vents**	**2.50m × 2Vents**	**2.50m × 2Vents**	**2.50m × 2Vents**	**1.50m × 2Vents**	-Most economical plan -2types of stoplogs are required (1.5mx2.45m, 2.5mx2.65m)
		Gate height	Hgate=2.30m	Hgate=2.65m	Hgate=2.25m	Hgate=2.45m	Hgate=2.45m	
		Flow area	Ar=4.95m^2 (<5.61)	Ar=10.00m^2 (>9.98)	Ar=8.00m^2 (>7.83)	Ar=9.00m^2 (>7.83)	Ar=5.40m^2 (<6.30)	
		Velocity	Vr=1.01m/s (1.0<Vr<1.5)	Vr=1.20m/s (1.0<Vr<1.5)	Vr=1.13m/s (1.0<Vr<1.5)	Vr=1.00m/s (1.0<Vr<1.5)	Vr=1.30m/s (1.0<Vr<1.5)	
		Width ratio (B1: Canal B2:Regulator)	B2/B1=0.67 (0.6～1.0)	B2/B1=0.67 (0.6～1.0)	B2/B1=1.20 (0.6～1.0)	B2/B1=1.20 (0.6～1.0)	B2/B1=0.67 (0.6～1.0)	
		Heading up	h=9.6cm (<10cm)	h=9.9cm (<10cm)	h=9.0cm (<10cm)	h=6.8cm (<10cm)	h=15.5cm/ 0.6cm ※	
		Cross section of regulator	 1.50 1.50 1.00 1.50 1.50 EL.47.50 EL.46.55 WL.46.30 2.30 EL.44.25	 1.50 2.50 1.00 2.50 1.50 EL.47.50 EL.46.55 WL.46.30 2.65 EL.43.90	 1.50 2.50 1.00 2.50 1.50 EL.47.50 EL.46.55 WL.46.30 2.25 EL.44.30	 1.50 2.50 1.00 2.50 1.00 1.50 1.00 1.50 1.50 EL.47.50 EL.46.55 WL.46.30 2.45 EL.44.10 EL.44.10 2.45 Irad Delgaw Abo Gabal		
		Concrete volume of main body(m^3)	772.2	669.5	639.2	1250.1		Cost ratio=1.00
		Bridge surface area(m^2)	-	100	100	-		
		Total gate leaf area(m2)	6.9	13.25	11.25	12.25	7.35	
		Civil works(Million USD)	0.28	0.31	0.30	0.46		
		Gate facilities(Million USD)	0.08	0.15	0.13	0.14	0.09	
		Stop logs (Million USD)	0.02					
		Total (Million USD)	1.97					
	CASE1B: 2 different width (2.0m x 2.5m) Slide gate (underflow)	Width and number of vents	**2.00m × 2Vents**	**2.50m × 2Vents**	**2.00m × 2Vents**	**2.00m × 2Vents**	**2.00m × 2Vents**	-Cost is almost same as CASE1A -2types of stoplogs are required (2.0mx2.65m, 2.5mx2.65m)
		Gate height	Hgate=1.90m	Hgate=2.65m	Hgate=2.65m	Hgate=2.40m	Hgate=2.40m	
		Flow area	Ar=5.00m^2 (<5.61)	Ar=10.00m^2 (>9.98)	Ar=8.00m^2 (>7.83)	Ar=7.00m^2 (<7.83)	Ar=7.00m^2 (>6.30)	
		Velocity	Vr=1.00m/s (1.0<Vr<1.5)	Vr=1.20m/s (1.0<Vr<1.5)	Vr=1.13m/s (1.0<Vr<1.5)	Vr=1.29m/s (1.0<Vr<1.5)	Vr=1.00m/s (1.0<Vr<1.5)	
		Width ratio (B1: Canal B2:Regulator)	B2/B1=0.83 (0.6～1.0)	B2/B1=0.67 (0.6～1.0)	B2/B1=1.00 (0.6～1.0)	B2/B1=1.00 (0.6～1.0)	B2/B1=0.83 (0.6～1.0)	
		Heading up	h=7.2cm (<10cm)	h=9.9cm (<10cm)	h=9.0cm (<10cm)	h=12.0cm/ 0.7cm ※	h=6.7cm (<10cm)	
		Cross section of regulator	 1.50 2.00 1.00 2.00 1.50 EL.47.50 EL.46.55 WL.46.30 1.90 EL.44.65	 1.50 2.50 1.00 2.50 1.50 EL.47.50 EL.46.55 WL.46.30 2.65 EL.43.90	 1.50 2.00 1.00 2.00 1.50 EL.47.50 EL.46.55 WL.46.30 2.65 EL.43.90	 1.50 2.00 1.00 2.00 1.00 2.00 1.00 2.00 1.50 EL.47.50 EL.46.55 WL.46.30 2.40 EL.44.15 EL.44.15 2.40 Irad Delgaw Abo Gabal		
		Concrete volume of main body(m^3)	886.8	669.5	621.7	1256.0		Cost ratio=1.02
		Bridge surface area(m^2)	-	100	87.5	-		
		Total gate leaf area(m2)	7.6	13.25	10.6	9.6	9.6	
		Civil works(Million USD)	0.33	0.31	0.29	0.46		
		Gate facilities(Million USD)	0.09	0.15	0.12	0.11	0.11	
		Stop logs (Million USD)	0.02					
		Total (Million USD)	2.00					

Note ; ( ) requirement by Egyptian code ※Heading up given by "h=αβV^2/2g" Exchange rate; $1=JPY121.93

Table 6-2.3 Comparison of width and number of vents for the small scale regulators (2/2)

(2/2)

Regulator Name			**New Sahelyia**	**New Badraman**		**New Abo Gabal**		**Rough cost ratio & Comments**
Canal Name			**Sahelyia**	**Diroutiah**	**Badraman**	**Irad Delgaw**	**Abo Gabal**	
Design discharge (m^3/s)			**5.0**	**12.0**	**9.0**	**9.0**	**7.0**	
Design cross section of regulators	**CASE1C: Uniform width (2.0m) Slide gate (underflow)**	Width and number of vents	**2.00m × 2Vents**	**2.00m × 3Vents**	**2.00m × 2Vents**	**2.00m × 2Vents**	**2.00m × 2Vents**	**Recommended plan** -Cost is almost same as CASE1A -Stoplog is only one type (2.0mx2.65m)
		Gate height	Hgate=1.90m	Hgate=2.35m	Hgate=2.65m	Hgate=2.40m	Hgate=2.40m	
		Flow area	Ar=5.00m^2 (<5.61)	Ar=10.20m^2 (>9.98)	Ar=8.00m^2 (>7.83)	Ar=7.00m^2 (<7.83)	Ar=7.00m^2 (>6.30)	
		Velocity	Vr=1.00m/s (1.0<Vr<1.5)	Vr=1.18m/s (1.0<Vr<1.5)	Vr=1.13m/s (1.0<Vr<1.5)	Vr=1.29m/s (1.0<Vr<1.5)	Vr=1.00m/s (1.0<Vr<1.5)	
		Width ratio (B1: Canal B2:Regulator)	B2/B1=0.83 (0.6〜1.0)	B2/B1=0.89 (0.6〜1.0)	B2/B1=1.00 (0.6〜1.0)	B2/B1=1.00 (0.6〜1.0)	B2/B1=0.83 (0.6〜1.0)	
		Heading up	h=7.2cm (<10cm)	h=9.5cm (<10cm)	h=9.0cm (<10cm)	h=12.0cm/ 0.7cm ※	h=6.7cm (<10cm)	
		Cross section of regulator	 1.50 2.00 1.00 2.00 1.50 EL.47.50 EL.46.55 WL.46.30 EL.44.65 1.90	 1.50 2.00 1.00 2.00 1.00 2.00 1.50 EL.47.50 EL.46.55 WL.46.30 EL.44.20 2.35	 1.50 2.00 1.00 2.00 1.50 EL.47.50 EL.46.55 WL.46.30 EL.43.90 2.65	 1.00 1.00 1.00 1.50 2.00 2.00 2.00 2.00 1.50 EL.47.50 EL.46.55 WL.46.30 2.40 EL.44.15 EL.44.15 2.40 Irad Delgaw Abo Gabal		
		Concrete volume of main body(m^3)	886.8	830.2	621.7	1256.0		Cost ratio=1.05
		Bridge surface area(m^2)	-	125.0	87.5	-		
		Total gate leaf area(m2)	7.6	14.1	10.6	9.6	9.6	
		Civil works(Million USD)	0.33	0.39	0.29	0.46		
		Gate facilities(Million USD)	0.09	0.16	0.12	0.11	0.11	
		Stop logs (Million USD)	0.01					
		Total (Million USD)	2.07					

Note ; ( ) requirement by Egyptian code ※Heading up given by "$h=\alpha\beta V^2/2g$" Exchange rate; $1=JPY121.93

(3) Result of additional considerations

The new hydraulic conditions provided by the Design Working Group on the two small regulators (Sahelyia and Abo Gabal regulators) are:

a) To be a structure capable of taking minimum discharge from the hydraulic view,

b) To be at the same apron level as the existing Sahelyia and Abo Gabal regulators.

As a result of the hydraulic evaluation and compliance with Egyptian code, the reasonable combinations of vent width, numbers, and sill levels are shown in Table 6-2.5. These results were approved by the meeting held shortly after the 19th TAC meeting.

The applied design of small regulators is shown in Table 6-2.4.

Table 6-2.4 Vent width and numbers of the two small scale regulators

Regulator name	Sahelyia	Badraman		Abo Gabal	
Canal name	Sahelyia	Diroutiah	Badraman	Irad Delgaw	Abo Gabal
Vent width	2.00m	2.00m	2.00m	2.00m	2.00m
Nos of vent	2 vents	3 vents	2 vents	2 vents	2 vents
Sill level	EL.43.00m	EL.44.20m	EL.43.90m	EL.43.60m	EL.43.60m

Table 6-2.5 Additional considerations on the two small scale regulators

Regulator Name					New Sahelyia								New Abo Gabal															
Canal Name					Sahelyia								Irad Delgaw								Abo Gabal							
Width and number of vents					2.00m × 2Vents				1.50m×2Vents				2.00m × 2Vents				1.50m × 2Vents				2.00m × 2Vents				1.50m × 2Vents			
					2Vents Open		1Vent Close		2Vents Open		1Vent Close		2Vents Open		1Vent Close		2Vents Open		1Vent Close		2Vents Open		1Vent Close		2Vents Open		1Vent Close	
Apron lebel				EL. (m)	43.00								43.60								43.60							
Max. design discharge			Max. design discharge (m^3/s)		5.0								9.0								7.0							
			U.S.W.L.	(m)	46.30								46.30								46.30							
			D.S.W.L.	(m)	45.90								45.90								45.90							
			Gate height	Hgate (m)	3.55								2.95								2.95							
	Regulator		Flow area	Ar (m^2)	11.60		5.80		8.70		4.35		9.20		4.60		6.90		3.45		9.20		4.60		6.90		3.45	
			Velocity	Vr (m/s)	0.43		0.86		0.57		1.15		0.98		1.96		1.30		2.61		0.76		1.52		1.01		2.03	
			Width	B2 (m)	5.00		2.00		4.00		1.50		5.00		2.00		4.00		1.50		5.00		2.00		4.00		1.50	
	Canal		Flow area	Ac (m^2)	16.56		16.56		16.56		16.56		23.40		23.40		23.40		23.40		19.09		19.09		19.09		19.09	
			Velocity	Vc (m/s)	0.30		0.30		0.30		0.30		0.39		0.39		0.39		0.39		0.37		0.37		0.37		0.37	
			Width	B1 (m)	4.50		4.50		4.50		4.50		3.30		3.30		3.30		3.30		6.00		6.00		6.00		6.00	
	Egyptian code	Check 1	2 < Vr/Vc < 3	Vr / Vc	1.42	NG	2.83	OK	1.89	NG	3.78	NG	2.50	OK	5.01	NG	3.34	NG	6.68	NG	2.06	OK	4.12	NG	2.74	OK	5.49	NG
			Vr =1.00~1.50m/s	Vr	0.43	NG	0.86	NG	0.57	NG	1.15	OK	0.98	NG	1.96	NG	1.30	OK	2.61	NG	0.76	NG	1.52	NG	1.01	OK	2.03	NG
		Check 2	0.6 < B2/B1< 1.0	B2 /B1	1.11	NG	0.44	NG	0.89	OK	0.33	NG	1.52	NG	0.61	OK	1.21	NG	0.45	NG	0.83	OK	0.33	NG	0.67	OK	0.25	NG
		Check 3	$h=Vc^2/(2gC^2)\times((Ac/Ar)^2-1)$ ≦ 10cm		0.73	OK	5.03	OK	1.84	OK	9.48	OK	6.33	OK	28.80	NG	12.16	NG	52.10	NG	3.43	OK	16.83	NG	6.90	OK	30.72	NG
			$h=\alpha\times\beta\times Vc^2/(2g)$ ≦ 10cm		0.18	OK	0.40	OK	0.29	OK	0.45	OK	0.61	OK	0.81	OK	0.71	OK	0.86	OK	0.47	OK	0.69	OK	0.58	OK	0.74	OK
Min. design discharge			Min. design discharge (m^3/s)		0.6								1.3								0.9							
			U.S.W.L.	(m)	44.30								44.30								44.30							
			D.S.W.L.	(m)	44.22								44.08								44.29							
	Regulator		Flow area	Ar (m^2)	4.88		2.44		3.66		1.83		1.92		0.96		1.44		0.72		2.76		1.38		2.07		1.04	
			Velocity	Vr (m/s)	0.12		0.25		0.16		0.33		0.68		1.35		0.90		1.81		0.33		0.65		0.43		0.87	
			Width	B2 (m)	5.00		2.00		4.00		1.50		5.00		2.00		4.00		1.50		5.00		2.00		4.00		1.50	
	Canal		Flow area	Ac (m^2)	3.76		3.76		3.76		3.76		5.98		5.98		5.98		5.98		4.63		4.63		4.63		4.63	
			Velocity	Vc (m/s)	0.16		0.16		0.16		0.16		0.24		0.24		0.24		0.24		0.19		0.19		0.19		0.19	
			Width	B1 (m)	4.50		4.50		4.50		4.50		3.30		3.30		3.30		3.30		6.00		6.00		6.00		6.00	
	Egyptian code	Check 1	2 < Vr/Vc < 3	Vr / Vc	0.75	NG	1.51	NG	1.01	NG	2.01	OK	2.84	OK	5.67	NG	3.78	NG	7.56	NG	1.68	NG	3.35	NG	2.24	OK	4.47	NG
			Vr =1.00~1.50m/s	Vr	0.12	NG	0.25	NG	0.16	NG	0.33	NG	0.68	NG	1.35	OK	0.90	NG	1.81	NG	0.33	NG	0.65	NG	0.43	NG	0.87	NG
		Check 2	0.6 < B2/B1< 1.0	B2 /B1	1.11	NG	0.44	NG	0.89	OK	0.33	NG	1.52	NG	0.61	OK	1.21	NG	0.45	NG	0.83	OK	0.33	NG	0.67	OK	0.25	NG
		Check 3	$h=Vc^2/(2gC^2)\times((Ac/Ar)^2-1)$ ≦ 10cm		-0.08	OK	0.28	OK	0.01	OK	0.65	OK	3.77	OK	16.36	NG	7.03	OK	29.42	NG	0.52	OK	2.94	OK	1.15	OK	5.45	OK
			$h=\alpha\times\beta\times Vc^2/(2g)$ ≦ 10cm		(0.05)	OK	0.06	OK	0.00	OK	0.09	OK	0.26	OK	0.32	OK	0.29	OK	0.33	OK	0.10	OK	0.18	OK	0.14	OK	0.19	OK
			Available water level (Non-uniform flow)	≦44.30m	44.22	OK	44.23	OK	44.23	OK	44.24	OK	44.10	OK	44.20	OK	44.12	OK	44.33	NG	44.30	OK	44.31	NG	44.30	OK	44.33	NG
【Japanese code】0.6≦Intake velocity (Vi)≦1.0				Vi (m/s)	0.38	NG	0.76	OK	0.51	NG	1.01	NG	0.83	OK	1.67	NG	1.11	NG	2.22	NG	0.65	OK	1.30	NG	0.86	OK	1.73	NG

7. Elevation of Main Structures

7-1 Sill elevation of apron

The elevation for the top of apron under the gate is determined by the location of the new regulators. The current bed elevation of the canal is set to avoid sediment problems, as there are no plans for the construction of a new canal.

The locations of the new regulators are grouped into two types: one for Abo Gabal and Sahelyia regulators, which are constructed upstream of the DGRs at a right angle against the flow direction (TYPE1), and another for Bahr Yusef, Badraman, and Ibrahimia regulators which are constructed downstream of the DGRs (TYPE2).

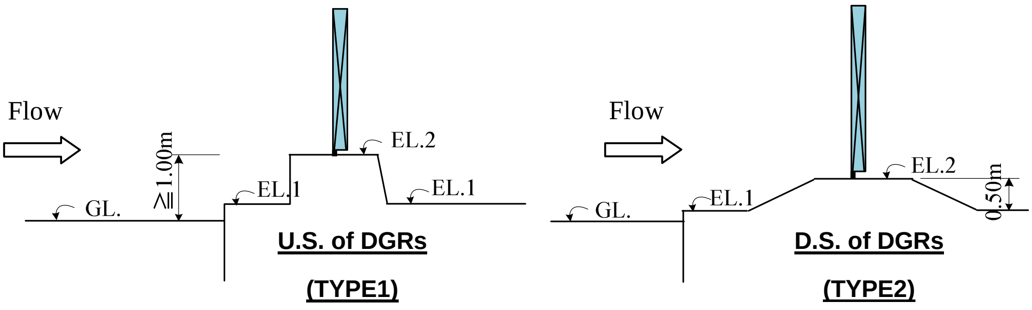
In response to strong requests from the Egyptian side, the sill level of the Abo Gabal and Sahelyia regulators should be of a particular height capable of taking water under the conditions of LLWL upstream with mini-discharge (refer to Chapter 6-2 (3)). The apron-apart from the sill parts-should be the same elevation as the existing one. In addition, the sill level should be 1.0m higher than the apron level. During the maintenance works for removing sedimentation, the elevation excavated should be less than the apron elevation (EL 1: refer to Figure 7-1.1)

The elevation of the latter type of regulators is set 0.5m higher than the current elevation of the upstream canal bed to account for unexpected sediments. Table 7-1.1 shows elevation of apron around gate sill.

Table 7-1.1 Elevation of apron around gate sill

Location Type	Regulator	Current canal bed GL.(m)	Elevation of the apron: EL.1 (m)[*1]	Elevation for the apron on the gate section: EL.2 (m)[*1]
U.S. of DGRs (TYPE1)	Abo Gabal	43.0±	42.75	43.60
	Sahelyia	44.0m±	41.55	43.00
D.S of DGRs (TYPE2)	Bahr Yusef	38.5～39.5	39.50	40.00
	Badraman	43.0±	43.40	43.90
	Diroutiah	43.5±	43.70	44.20
	Ibrahimia	39.5±	39.50	40.00

***1 : refer to Figure 7-1.1**



U.S. of DGRs (TYPE1)

D.S. of DGRs (TYPE2)

Figure 7-1.1 Schematic drawing for the elevation of apron around gate sill

7-2 Gate top elevation and height

The top elevation of the gate is designed as EL.46.55m (Upstream Design High Water Level 46.30m + Free Board 0.25m).

- Upstream Design High Water Level: US.H.W.L.= 46.30m
- Free Board: Fb = 0.25m

(Egyptian Code "Vol.3. Chap.5 Regulators and Gates")

- Top Elevation of the gate: EL.3=US.H.W.L.46.30m＋0.25m

= EL. 46.55m

The height of the gate is designed as the difference in elevation between the top of the gate and the apron on the gate section, as shown in Table 7-2.1.

Table 7-2.1 Gate height for each regulator

Regulator	Top elevation of the gate EL.3	Elevation of the apron on the gate section EL.2	Gate height H (m)	Remarks
Bahr Yusef	46.55m	40.00m	6.55m	Double leaf
Ibrahimia	46.55m	40.00m	6.65m	Double leaf
Sahelyia	46.55m	43.00m	3.55m	Single leaf
Diroutiah	46.55m	44.20m	2.35m	Single leaf
Badraman	46.55m	43.90m	2.65m	Single leaf
Abo Gabal	46.55m	43.60m	2.95m	Single leaf

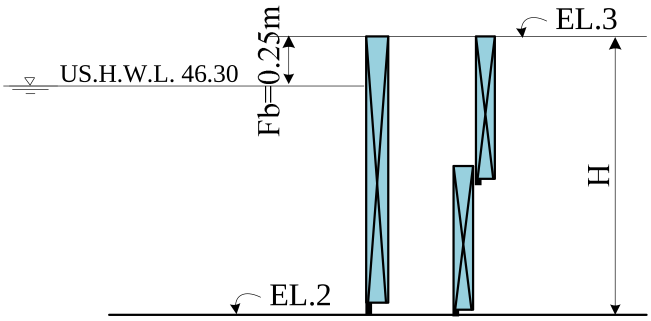


Figure 7-2.1 Schematic drawing for top elevation of the gate and its height

7-3 Bottom elevation of gate when fully opened

Bottom elevation of the fully open gate is designed as EL.47.50m (Upstream Unusual High Water Level 47.00m + Free board 0.50m).

・Upstream Unusual High Water Level: US.H.H.W.L.= 47.00m

・Free Board: Fb = 0.50m

(Egyptian Code “Vol.3. Chap.5 Regulators and Gates”)

・Bottom elevation of the fully open gate: EL.4 = US.H.H.W.L.47.00m＋0.50m = EL.47.50m

7-4 Elevation of downstream at the end of apron

As for the elevation at the end of the apron, the harmful effects of scoring should be considered to avoid damage to the apron and promote regulator longevity. Since the existing canal elevation at the downstream is higher than that at the design apron level, the long-term stability of the regulators and their safety from serious damage is ensured with flat apron design.

Accordingly, "EL 1" in Chapter 7-1" should be the downstream design apron level.

8. Design of Weir Body

8-1 Design of weir body

Since the foundation is composed of unconsolidated sand, silt, or clay, the regulator is of the 'floating' type. For this regulator type, the design of the length of the apron and the thickness of the regulator body complies with Egyptian Code "Vol.3. Chapter 5 Regulators and Gates" and *Part No.2 Design of Hydraulic Structures Spillways Regulators Barrage* as below.

(1) Length of downstream apron

Bligh's equation is applied to the length of the downstream apron, which is shown below.

$$Ls = 0.61 \times C \times \sqrt{H}$$

Where, Ls: Length of downstream apron (m)

C: Constant of Bligh equation

⊿H: Maximum difference between upstream and downstream in water level (m)

(2) Creep length

In order to prevent piping, it is necessary to keep enough creep length along the foundation of the regulator. Required creep length is selected as the largest of the values calculated by Bligh's method and Lane's method

① Bligh's method

$$S' \geqq C \times \triangle H$$

Where, S': Creep length along the foundation of the regulator (m)

C: Constant of Bligh's equation

⊿H: Maximum difference between upstream and downstream in water level (m)

② Lane's method

$$L' \geqq C' \times \triangle H$$

Where, L': Creep length along the foundation of the regulator (m)

C': Weighted Creep constant for Lane's method

⊿H: Maximum difference between upstream and downstream in water level (m)

Table 8-1.1 Constant values for each method

Geological feature	C : Bligh	C' : Lane
Fine sand	15	7
Heavy clay	4	1.8

(3) Thickness of regulator body

The thickness of the middle and downstream apron is determined by the balance of uplift pressure under the apron.

$$t = 1.3 \times \frac{\triangle H - Hf}{\gamma - 1} - \frac{Hu \times t0}{S + t0}$$

Where, t: Required thickness of apron at the calculation point (m)

$\triangle$H: Maximum difference between upstream and downstream in water level (m)

Hf: Head loss of the seepage water up to the calculation point (m)

γ : Specific gravity of the material for apron (kN/m^2)

1.3: Safety Factor

Hu: Height of the middle pier (m)

t0: Thickness of the middle pier (m)

S: Vent Width (m)

(4) Results

Figure 8-1.1 to 8-1.4 show the summary results of the hydraulic design to determine the dimensions of the apron and the regulator body. The dimensions of the apron of the new Sahelyia and Abo Gabal regulators are the same as those of the existing apron, as the new apron will be connected to the existing one.

Results of Hydraulic Design —Bahr-Yusef Reg.—

(3) Thickness of apron

Lost water head at Point A : $Hf_A = \Delta H \times L_A / \Sigma L = 6.80 \times 34.15 / 102.40 = 2.27m$

Lost water head at Point B : $Hf_B = \Delta H \times L_B / \Sigma L = 6.80 \times 39.65 / 102.40 = 2.63m$

Lost water head at Point C : $Hf_C = \Delta H \times L_C / \Sigma L = 6.80 \times 68.40 / 102.40 = 4.54m$

Lost water head at Point D : $Hf_D = \Delta H \times L_D / \Sigma L = 6.80 \times 89.40 / 102.40 = 5.94m$

a) At Point A

$t_A = 1.3 \times (\Delta H - Hf_A)/(\gamma - 1) - Hu \times t_0/(S + t_0)$

$= 1.3 \times (6.80 - 2.27)/(2.50 - 1) - 7.50 \times 2.50/(6.00 + 2.50) = \underline{1.72m}$

b) At Point B

$t_B = 1.3 \times (\Delta H - Hf_B)/(\gamma - 1) - Hu \times t_0/(S + t_0)$

$= 1.3 \times (6.80 - 2.63)/(2.50 - 1) - 7.00 \times 2.50/(6.00 + 2.50) = \underline{1.56m}$

c) At Point C

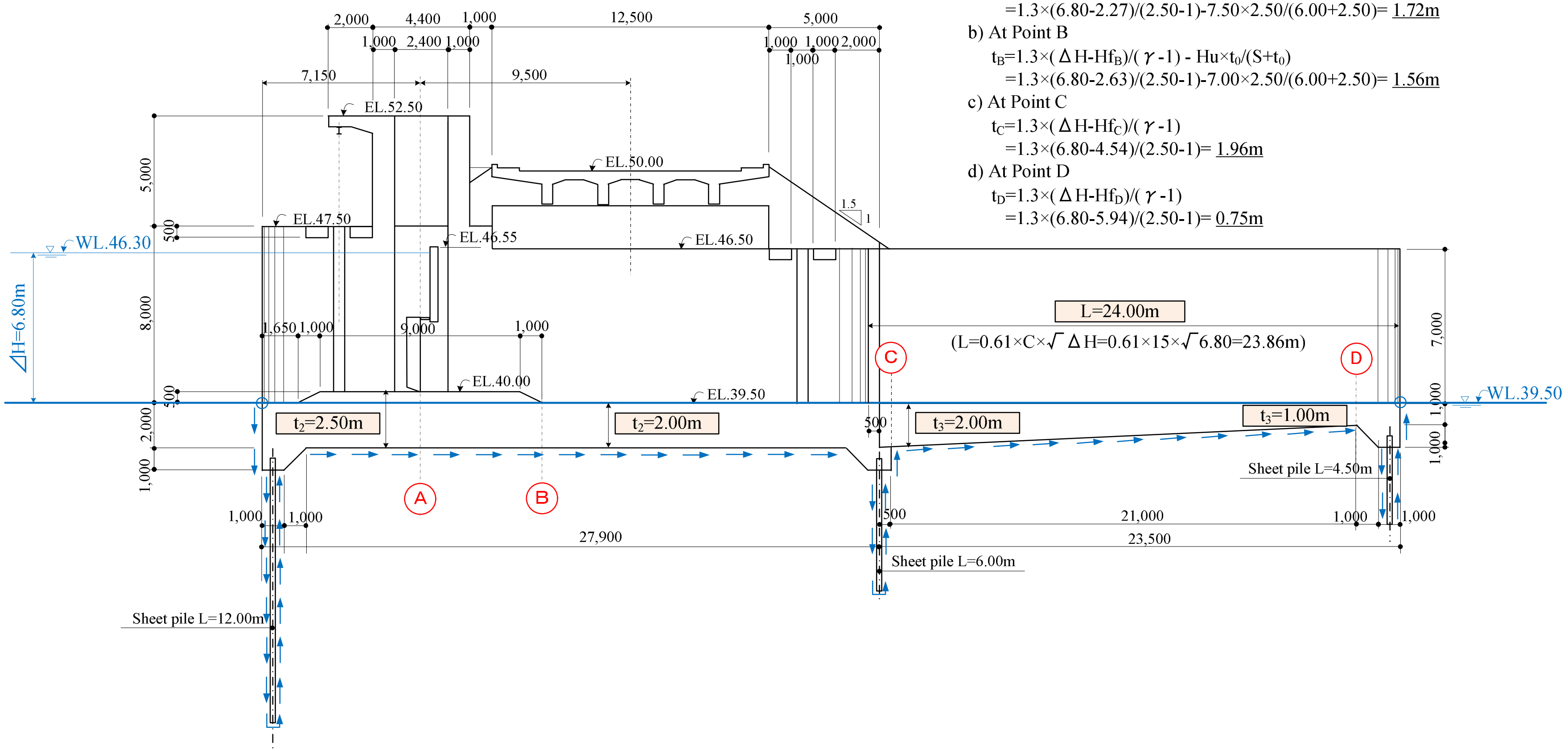
$t_C = 1.3 \times (\Delta H - Hf_C)/(\gamma - 1)$

$= 1.3 \times (6.80 - 4.54)/(2.50 - 1) = \underline{1.96m}$

d) At Point D

$t_D = 1.3 \times (\Delta H - Hf_D)/(\gamma - 1)$

$= 1.3 \times (6.80 - 5.94)/(2.50 - 1) = \underline{0.75m}$



(1) Design creep length

Horizontal creep length : $\Sigma H = 27.90 + 23.50 = 51.40m$

Vertical creep length : $\Sigma V = 3.00 + 11.5 \times 2 + 1.00 + 1.00 + 5.50 \times 2 + 1.00 + 1.00 + 4.00 \times 2 + 2.00 = 51.00m$

Design creep length : $\Sigma L = \Sigma V + \Sigma H = 102.40m$

(2) Piping

a) Bligh method : $S' = C \times \Delta H = 15 \times 6.80 = 102.00m$

$\leqq S = \Sigma L = 102.40m$ (OK)

b) Lane method : $L' = C' \times \Delta H = 7 \times 6.80 = 47.60m$

$\leqq L = \Sigma V + 1/3 \Sigma H = 51.00 + 1/3 \times 51.40 = 68.13m$ (OK)

Figure 8-1.1 Result of the hydraulic design for the length of apron and the thickness of the regulator body (Bahr Yusef regulator)

Results of Hydraulic Design －Ibrahimia Reg.－

(3) Thickness of apron

Lost water head at Point A : $Hf_A = \Delta H \times L_A / \Sigma L = 6.80 \times 34.15/102.40 = 2.27m$

Lost water head at Point B : $Hf_B = \Delta H \times L_B / \Sigma L = 6.80 \times 39.65/102.40 = 2.63m$

Lost water head at Point C : $Hf_C = \Delta H \times L_C / \Sigma L = 6.80 \times 68.40/102.40 = 4.54m$

Lost water head at Point D : $Hf_D = \Delta H \times L_D / \Sigma L = 6.80 \times 89.40/102.40 = 5.94m$

a) At Point A

$t_A = 1.3 \times (\Delta H - Hf_A)/(\gamma - 1) - Hu \times t_0/(S+t_0)$

$= 1.3 \times (6.80-2.27)/(2.50-1) - 7.50 \times 2.50/(6.00+2.50) = \underline{1.72m}$

b) At Point B

$t_B = 1.3 \times (\Delta H - Hf_B)/(\gamma - 1) - Hu \times t_0/(S+t_0)$

$= 1.3 \times (6.80-2.63)/(2.50-1) - 7.00 \times 2.50/(6.00+2.50) = \underline{1.56m}$

c) At Point C

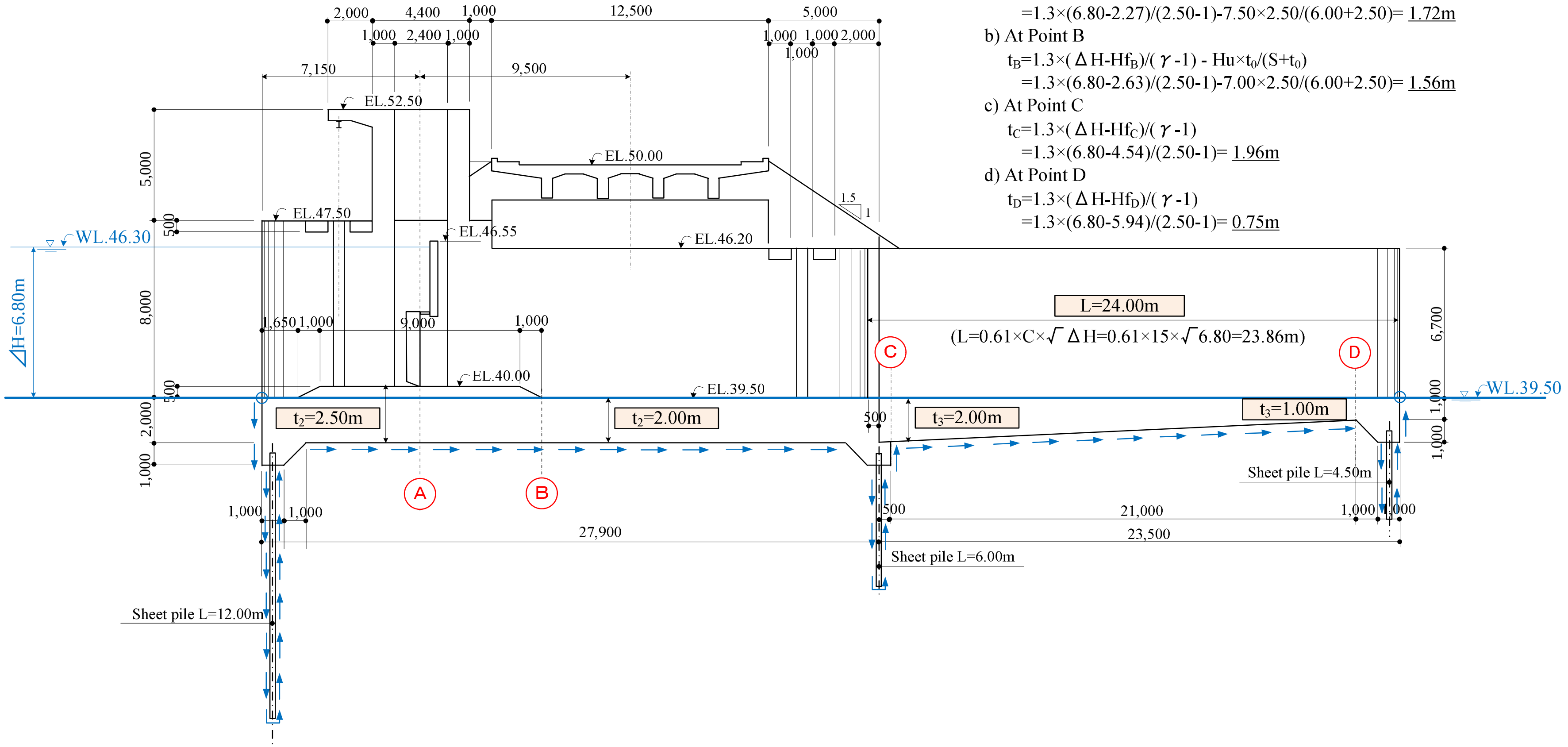
$t_C = 1.3 \times (\Delta H - Hf_C)/(\gamma - 1)$

$= 1.3 \times (6.80-4.54)/(2.50-1) = \underline{1.96m}$

d) At Point D

$t_D = 1.3 \times (\Delta H - Hf_D)/(\gamma - 1)$

$= 1.3 \times (6.80-5.94)/(2.50-1) = \underline{0.75m}$



(1) Design creep length

Horizontal creep length : $\Sigma H = 27.90+23.50 = 51.40m$

Vertical creep length : $\Sigma V = 3.00+11.5 \times 2+1.00+1.00$
$+5.50 \times 2+1.00+1.00+4.00 \times 2+2.00 = 51.00m$

Design creep length : $\Sigma L = \Sigma V + \Sigma H = 102.40m$

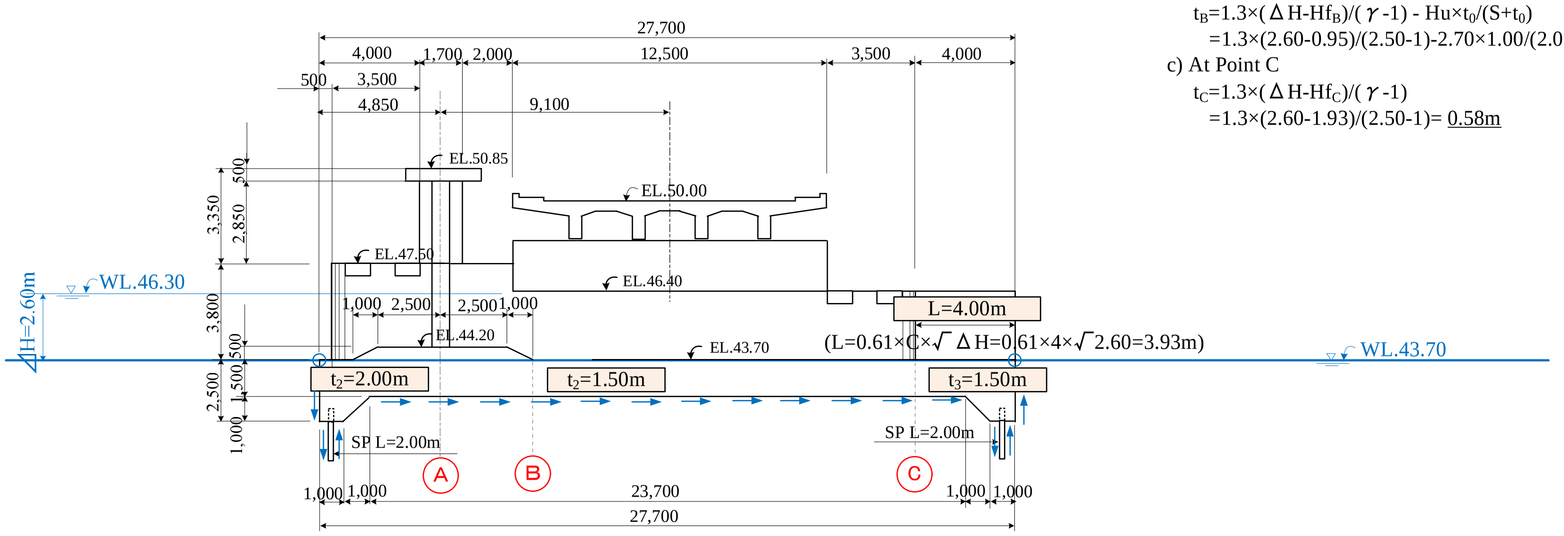
(2) Piping

a) Bligh method : $S' = C \times \Delta H = 15 \times 6.80 = 102.00m$
$\leqq S = \Sigma L = 102.40m$ (OK)

b) Lane method : $L' = C' \times \Delta H = 7 \times 6.80 = 47.60m$
$\leqq L = \Sigma V + 1/3 \Sigma H = 51.00 + 1/3 \times 51.40 = 68.13m$ (OK)

Figure 8-1.2 Result of the hydraulic design for the length of apron and the thickness of the regulator body (Ibrahimia regulator)

Results of Hydraulic Design －Diroutiah Reg.－



(3) Thickness of apron

Lost water head at Point A : $Hf_A=\Delta H\times L_A/\Sigma L=2.60\times 11.35/40.70=0.73$m

Lost water head at Point B : $Hf_B=\Delta H\times L_B/\Sigma L=2.60\times 14.85/40.70=0.95$m

Lost water head at Point C : $Hf_C=\Delta H\times L_C/\Sigma L=2.60\times 30.20/40.70=1.93$m

a) At Point A

$t_A=1.3\times(\Delta H-Hf_A)/(\gamma-1)$ - $Hu\times t_0/(S+t_0)$

$=1.3\times(2.60-0.73)/(2.50-1)-3.30\times 1.00/(2.00+1.00)=$ $\underline{0.52\text{m}}$

b) At Point B

$t_B=1.3\times(\Delta H-Hf_B)/(\gamma-1)$ - $Hu\times t_0/(S+t_0)$

$=1.3\times(2.60-0.95)/(2.50-1)-2.70\times 1.00/(2.00+1.00)=$ $\underline{0.53\text{m}}$

c) At Point C

$t_C=1.3\times(\Delta H-Hf_C)/(\gamma-1)$

$=1.3\times(2.60-1.93)/(2.50-1)=$ $\underline{0.58\text{m}}$

(1) Design creep length

Horizontal creep length : $\Sigma H=27.70$m

Vertical creep length : $\Sigma V=2.50+1.5\times 2+1.00+1.00+1.50\times 2+2.50=13.00$m

Design creep length : $\Sigma L=\Sigma V+\Sigma H=40.70$m

(2) Piping

a) Bligh method : $S'=C\times\Delta H=4\times 2.60=10.40$m

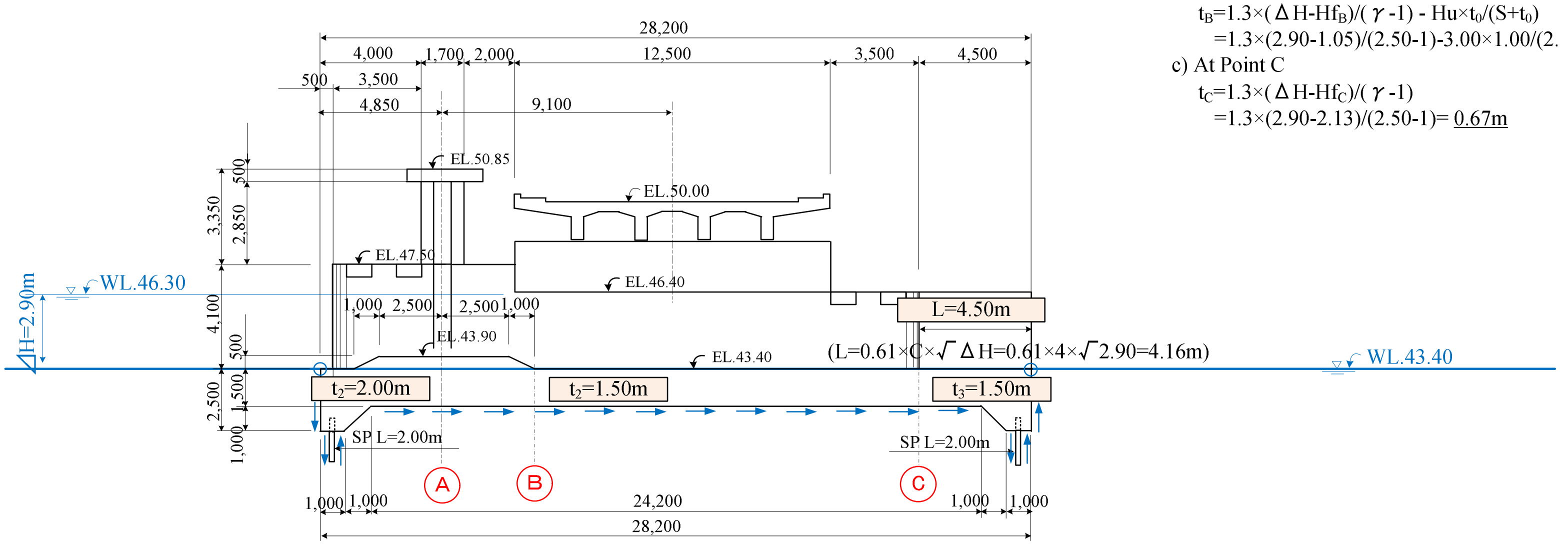
$\leqq S=\Sigma L=40.70$m (OK)

b) Lane method : $L'=C'\times\Delta H=1.8\times 2.60=4.68$m

$\leqq L=\Sigma V+1/3\,\Sigma H=13.00+1/3\times 27.70=22.23$m (OK)

Figure 8-1.3 Result of the hydraulic design for the length of apron and the thickness of the regulator body (Diroutiah regulator)

Results of Hydraulic Design −Badraman Reg.−



(1) Design creep length

Horizontal creep length :ΣH＝28.20m

Vertical creep length :ΣV＝2.50+1.5×2+1.00+1.00+1.50×2+2.50=13.00m

Design creep length :ΣL＝ΣV＋ΣH＝41.20m

(2) Piping

a) Bligh method : S’=C×ΔH=4×2.90=11.60m

≦ S=ΣL=41.20m (OK)

b) Lane method : L’=C’×ΔH=1.8×2.90=5.22m

≦ L=ΣV+1/3ΣH=13.00+1/3×28.20=22.40m (OK)

(3) Thickness of apron

Lost water head at Point A : $Hf_A=\Delta H\times L_A/\Sigma L=2.90\times 11.35/41.20=0.80m$

Lost water head at Point B : $Hf_B=\Delta H\times L_B/\Sigma L=2.90\times 14.85/41.20=1.05m$

Lost water head at Point C : $Hf_C=\Delta H\times L_C/\Sigma L=2.90\times 30.20/41.20=2.13m$

a) At Point A

$t_A=1.3\times(\Delta H-Hf_A)/(\gamma-1) - Hu\times t_0/(S+t_0)$

$=1.3\times(2.90-0.80)/(2.50-1)-3.60\times 1.00/(2.00+1.00)=$ 0.62m

b) At Point B

$t_B=1.3\times(\Delta H-Hf_B)/(\gamma-1) - Hu\times t_0/(S+t_0)$

$=1.3\times(2.90-1.05)/(2.50-1)-3.00\times 1.00/(2.00+1.00)=$ 0.60m

c) At Point C

$t_C=1.3\times(\Delta H-Hf_C)/(\gamma-1)$

$=1.3\times(2.90-2.13)/(2.50-1)=$ 0.67m

Figure 8-1.4 Result of the hydraulic design for the length of apron and the thickness of the regulator body (Badraman regulator)

8-2 Design of downstream apron

The downstream apron should be designed for the protection of the bed in the large Bahr Yusef and Ibrahimia regulators, whose structures are separated into weir body and apron. The downstream aprons are 31.5m long at the bottom and are structured in a U-shape. Their shape is different from the weir body, with a middle pier on the bottom slab.

Although the Egyptian side requested a U-shaped structure, (a single body structure connected to two side walls and a bottom slab) an evaluation of structure and foundation types showed that the L-type structure of an L-type wall and an apron slab should be used. The foundation type selected should be of the pile foundation type in conformity with the regulators.

These decisions were approved by 22nd TAC, and the comparisons and evaluations are shown in Table 8-2.1.

Table 8-2.1 Comparison table of wall types at downstream apron (1/3)

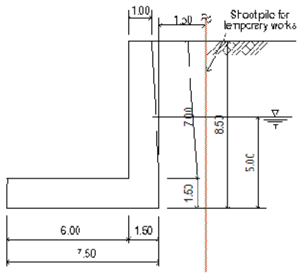
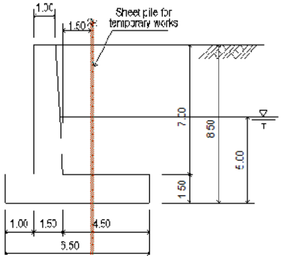
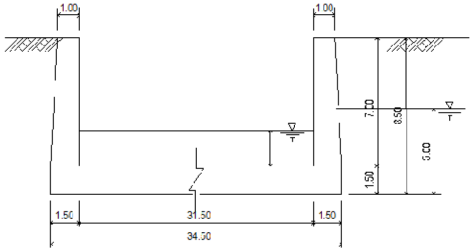
Type	L type wall	T type wall	U type (Raft foundation and one body)
Structure design	 1.00 1.50 Shootpile for temporary works 7.00 8.50 5.00 1.50 6.00 1.50 7.50	 1.00 1.50 Sheet pile for temporary works 7.20 8.50 6.00 1.50 1.00 1.50 4.50 5.50 Note: thickness of footing is 1.5m, same as the regulator apron. If it is over 2m, temporary double sheet pile will be unstable.	 1.00 1.00 7.20 8.50 6.00 1.50 1.50 31.50 1.50 34.50 Note: thickness of footing is 1.5m, same as regulator footing. If it is over 2m, temporary double sheet pie will be unstable.
Stability of raft foundation structure ・for land sliding ・for eccentricity	Safe stability is not secured because of substantial horizontal stress. 1) normal condition: Fs= 0.504 < 1.5 ・・・・・・・・NG e=1.256 > 1.250 = B/6 ・・NG 2) seismic condition: Fs– 0.442 < 1.15 ・・・・・・・NG e= -0.688 < 2.500 = B/3 ・・OK **(No good)**	Safe stability is secured as follows: 1) normal condition: Fs= 1.606 > 1.5 ・・・・・・・・OK e=0.773 < 1.083 = B/6 ・・OK 2) seismic condition: Fs= 1.653 > 1.15 ・・・・・・・OK e= 0.647 < 2.167 = B/3···OK **(Good)**	Safe stability is secured as follows: 1) symmetry structural form 2) offset of horizontal stress. ⇒Stable OK **(Good)**
Stability of bearing capacity of raft foundation	The actual stress to the ground is larger than the allowable bearing capacity because of the large eccentricity, so it is **not used as the raft foundation.** Measurements of foundation type: 1) normal condition: q− 68.53 kN/m2 > range out・・・NG (6.85 tf/m2) 2) seismic condition: q= 82.84 kN/m2 > range out・・・NG (8.28tf/m2) **(No good)**	The actual stress to the ground is larger than the allowable bearing capacity because of the great eccentricity, so it is **not used as the raft foundation.** Measurements of foundation type: 1) normal condition: q− 215.20 kN/m2 > range out・・・NG (21.5tf/m2) 2) seismic condition: q= 239.49 kN/m2 > range out・・・NG (23.95tf/m2) **(No good)**	The actual stress to the ground at Bahr Yusef is larger than the allowable bearing capacity, but at Ibrahimia it is within allowable bearing capacity. 1) normal condition: q− 50.18 kN/m2 > 49.16 kN/m2・・NG < 91.48 kN/m2・・OK (5.02tf/m2 > 4.92tf/m2) (< 9.15tf/m2) *: upper value: Bahr Yusef, lower value: Ibrahimia **(Moderate)**

Table 8-2.2 Comparison table of wall types at downstream apron (2/3)

Type		L type wall	T type wall		U type (Raft foundation and one body)	
Structural stress Note) Available steel bar should be **less than φ25mm** in the comparison table for marketability.		Following bar arrangement is applied. 1) Wall: φ22@200mm 2) Footing: φ25@200mm ⇒Structural stress safety →OK **(Good)**	Following bar arrangement is applied. 1) Wall: φ22@200mm 2) Footing: φ25@200mm ⇒Structural stress safety →OK **(Good)**		Following bar arrangement is applied. 1) Wall: φ22@200mm 2) Footing: φ25@100mm ⇒Structural stress without safety →NG Note) Long footing is affected by strong moment especially at the center of footing. **(No good)**	
Wall	B, H, d (mm)	1000, 1500, 1430	1000, 1500, 1430		1000, 1500, 1430	
	M (kN·m)	377.19 (37.72tf·m)	377.19 (37.72tf·m)		376.66 (37.67tf·m)	
	N (kN)	0.00	0.00		0.00	
	S (kN)	165.19 (16.52tf·m)	165.19 (16.52tf·m)		183.82 (18.38tf·m)	
	Bar-arrange	φ22@200mm	φ22@200mm		φ22@200mm	
	σc / σca (N/mm2)	2.05 < 9.50 ←OK (20.5kgf/cm2 < 95kgf/cm2)	2.05 < 9.50 ←OK (20.5kgf/cm2 < 95kgf/cm2)		2.15 < 9.50 ←OK (20.5kgf/cm2 < 95kgf/cm2)	
	σs / σsa (N/mm2)	144.64 < 200.0 ←OK (1446.4kgf/cm2 < 2000kgf/cm2)	144.64 < 200.0 ←OK (1446.4kgf/cm2 < 2000kgf/cm2)		144.85 < 200.0 ←OK (1448.5kgf/cm2 < 2000kgf/cm2)	
	τc / τca (N/mm2)	0.116 < 0.7 ←OK (1.16kgf/cm2 < 7.0kgf/cm2)	0.116 < 0.7 ←OK (1.16kgf/cm2 < 7.0kgf/cm2)		0.129 < 0.7 ←OK (1.29kgf/cm2 < 7.0kgf/cm2)	
Footing	B, H, d (mm)	1000, 1500, 1430	1000, 1500, 1430		1000, 1500, 1430	
	M (kN·m)	377.19 (37.72tf·m)	**(Front footing)** -92.65(9.27tf·m)	**(Back footing)** 377.19 (37.72tf·m)	**(Edge of footing)** 376.67(37.67tf·m)	**(Center of footing)** -6192.41(619.24tf·m)
	N (kN)	0.00	0.00	0.00	0.00	0.00
	S (kN)	205.68 (20.57tf·m)	181.61 (18.16tf·m)	183.69 (18.37tf·m)	796.257 (79.63tf·m)	0.00
	Bar-arrange	φ25@200mm **(Dia. comply with U type)**	φ25@200mm **(Dia. comply with U type)**	φ25@200mm **(Dia. comply with U type)**	φ25@**100mm**	φ25@**100mm**
	σc / σca (N/mm2)	1.93 < 9.50 ←OK (19.3kgf/cm2 < 95kgf/cm2)	0.47 < 9.50 ←OK (4.7kgf/cm2 <95kgf/cm2)	1.93 < 9.50 ←OK (19.3kgf/cm2 <95kgf/cm2)	2.15 < 9.50 ←OK (21.5kgf/cm2 <95kgf/cm2)	**24.07 > 9.50**←NG (240.1kgf/cm2 >95kgf/cm2)
	σs / σsa (N/mm2)	111.77 < 200.0 ←OK (1117.7kgf/cm2 < 2000kgf/cm2)	27.45 < 200.0 ←OK (274.5kgf/cm2 < 2000kgf/cm2)	111.77 < 200.0 ←OK (1117.7kgf/cm2 < 2000kgf/cm2)	144.85 < 200.0 ←OK (1448.5kgf/cm2 < 2000kgf/cm2)	**941.62 > 200.0**←NG (9416.2kgf/cm2 > 2000kgf/cm2)
	τc / τca (N/mm2)	0.144 < 0.7 ← OK (1.44kgf/cm2 < 7.0kgf/cm2)	0.127 < 0.7 ←OK (1.3kgf/cm2 < 7.0kgf/cm2)	0.129 < 0.805 ←OK (1.3kgf/cm2 < 8.05kgf/cm2)	0.557 < 0.7 ←OK (5.6kgf/cm2 < 7.0kgf/cm2)	—

Table 8-2.3 Comparison table of wall types at downstream apron (3/3)

Type	L type wall	T type wall	U type (Raft foundation and one body)
Impact on construction	No negative impact on the construction works, but (pile) foundation works are needed for stability. **(Good)**	The back footing causes adverse effects to the double sheet piles of the diversion works. Considering the necessary length of back footing, the diversion area is forced to become narrow and the flow velocity becomes high. **(No good)**	Due to the large steel bar volume, footing must be thicker, due to the long span footing. The deep digging required for the deep footing causes high stress to the sheet pile of the diversion works. The concrete needs careful casting to avoid temperature stress cracks if the footing is very thick. However, the thick footing causes excess weight to the allowable bearing capacity. **(No good)**
General evaluation and possibility of raft foundation	Raft foundation is not applied. Suitable measurements of the foundation shall be made. L-type wall is the most reasonable wall type for the Bahr Yusef and Ibrahimia regulators. **(Applied)**	Raft foundation is not applied. Even if the length of backward footing is secured by the required one, the diversion area in the construction stage cannot be secured at safe flow velocity. T-type wall is not the best type for the Bahr Yusef and Ibrahimia regulators.	Raft foundation is not applied in Bahr Yusef. Ibrahimia might be available for raft foundation from the viewpoint of bearing capacity, but large moment and stress act on the footing. To ensure regulator longevity, it should avoid this stressful structure. U-type is not the best type for the Bahr Yusef and Ibrahimia regulators.

Remarks: Buttress type cannot be applied under the condition of low bearing capacity. Buttress type is usually effective under the following conditions: 1) high stress acting on a vertical wall 10m or higher, 2) high stress acting on backward footing due to the heavy weight of the embankment.

9. Design of Canal Bed Protection

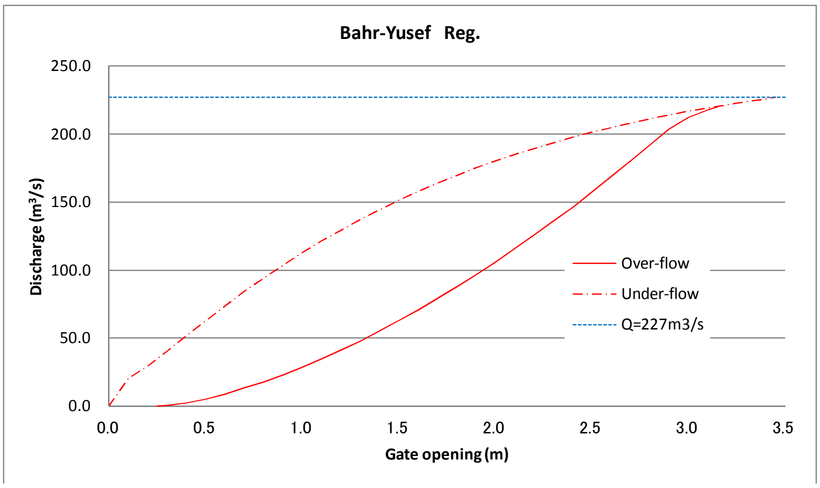
9-1 Basic design concept

The purpose of the bed protection works is to protect the dissipation and the local scouring downstream due to the high flow velocity. In the basic concept of design, the high flow velocity is gradually dissipated by the friction acting on the bed protection until it is the same velocity as that downstream of the canal at the end of the bed protection. This assumes that flowing beyond the limit of sediment movement has continuity of sediment transport, and equilibrium of the canal bed is preserved.

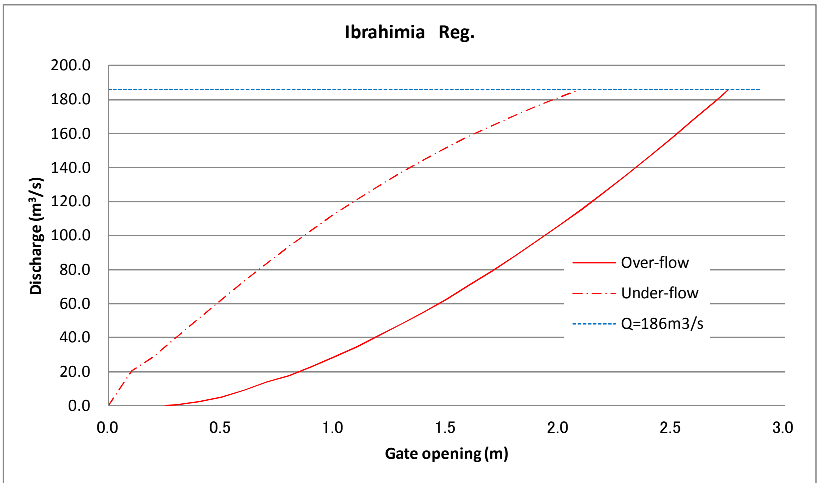
9-2 Length of canal bed protection

(1) Applicable gate operation for the new Bahr Yusef and Ibrahimia regulators

Underflow (submerged flow) gate operation is necessary for the new Bahr Yusef regulator when large discharge is required (refer to the upper chart of Figure 9-2.1). On the other hand, overflow gate operations can be applied to the new Ibrahimia regulator in any case (refer to the lower chart of Figure 9-2.1).



New Bahr Yusef regulator

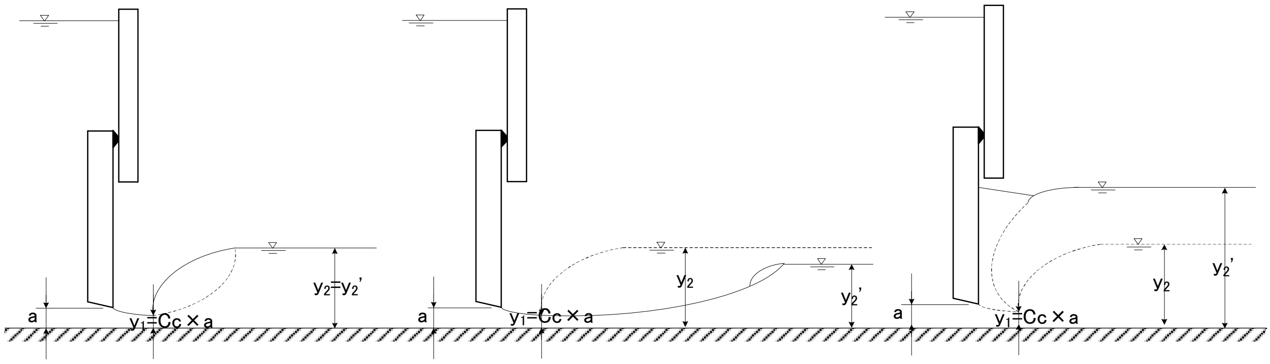


New Ibrahimia regulator

Figure 9-2.1 Relation between gate opening and discharge

(2) Type of hydraulic jump

The type of hydraulic jump which occurs just downstream of the gate is classified into three cases based on the relation between sequent depth (y2) and tailwater depth (y2’) (refer to Figure 9-2.2).

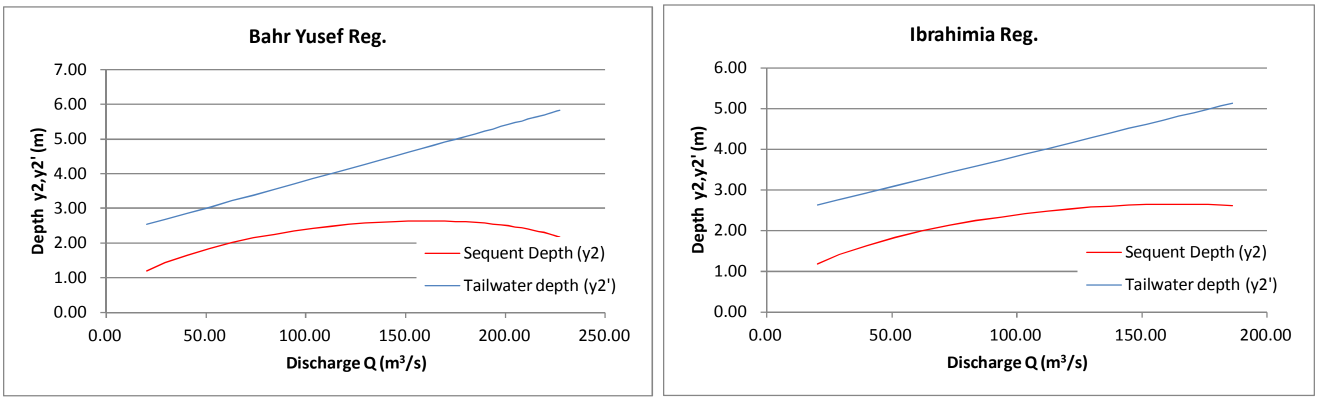


CASE 1 ($y_2 = y_2'$) CASE 2 ($y_2>y_2'$) CASE 3 ($y_2<y_2'$)

Figure 9-2.2 Type of hydraulic jump

The study of the bed protection should consider the flow state in the case of underflow operation, assuming garbage flushing maintenance takes place.

The result of the study of the relation between sequent depth and tailwater depth at each discharge volume is shown in Figure 9-2.3. The tailwater depth (y2’) is always larger than the sequent depth (y2) at any discharge volume, which is classified in case 3 of Figure 9-2.2.



New Bahr Yusef regulator New Ibrahimia regulator

Figure 9-2.3 Relation between sequent depth (y2) and tailwater depth (y2’) at each discharge

The results indicate that flow state is classified as submerged flow, not exposed jet flow, or exposed hydraulic jump as in cases 1 and 2 in Figure 9-2.2.

(3) Determination of the length of bed protection

Judging from the abovementioned flow conditions just downstream of the gate, the energy for the hydraulic jump is found to be completely dissipated in the area of the downstream apron for both new regulators (and the flow state after the apron section is considered steady).

Therefore, the length of the bed protection is designed more as a connection canal, not as an energy dissipater.

Following numerous experiences in Japan, the length of the apron of a connection canal is recommended to be three to five times the design water depth (H). Thus, considering safety, the length is designed to be 30m (5 times H) from the downstream apron of both new Bahr Yusef and Ibrahimia regulators.

Table 9-2.1 Length of downstream bed protection (new Bahr Yusef and Ibrahimia regulators)

Regulator	Downstream water level DS.HWL	Elevation of downstream apron EL end	Design water depth H	Length of bed protection	
				(3～5 H)	Applied
New Bahr Yusef regulator	45.82 m	39.50 m	6.32 m	18.96~31.60m	➡30.00m
New Ibrahimia regulator	45.13 m	39.50 m	5.63 m	16.89~28.15m	➡30.00m

(4) Determination of the length of the bed protection (New Badraman regulator)

As for the new Badraman regulator, the same method as that applied to the two large regulators is used. The new Badraman regulator (toward both Badraman and Ditoutiah canals) is designed to be 15m in length, as shown in Table 9-2-2.

Table 9-2.2 Length of downstream bed protection (new Badraman regulator)

Regulator	Downstream water level DS.HWL	Elevation of downstream apron EL end	Design water depth H	Length of bed protection	
				(3～5 H)	Applied
New Badraman	45.90 m	43.40 m	2.50 m	7.50~12.50m	➡15.00m
New Ditoutiah	45.90 m	43.70 m	2.20 m	6.60~11.00m	➡15.00m

【Reference: Japanese design standard】

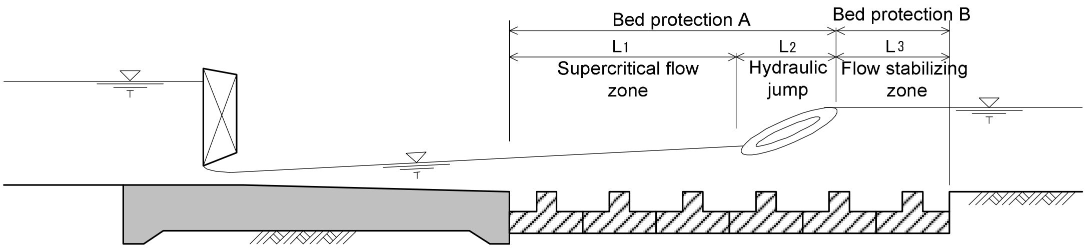


Figure 9-2.4 Design concept of bed protection in Japan

9-3 Stone size for the canal bed protection

(1) Applied formula

A large number of researchers in institutes have suggested various formulae to determine suitable riprap weight and size for certain flow states.

In this study, those riprap properties were calculated corresponding to the flow velocity using the following four formulae, which take into account the relatively gentle flow state.

- Isbash method (Isbash 1936)

$$V = C \times \left[2 \times g \times \frac{\gamma s - \gamma w}{\gamma w}\right]^{0.5} \times (D_{50})^{0.50}$$

$$D_{50} = \left[\frac{8 \times W_{50}}{\pi \gamma_s}\right]^{1/3}$$

Where,

V : Average flow velocity (ft/s)
C : C=1.20
g : Accelerationof gravity (g=32.2 ft/s^2)
γ_s : Weight of riprap (γ_s=137 lb/ft^3)
γ_w : Weight of water (γ_w=62.5 lb/ft^3)
D_{50} : Average diameter of a riprap (ft)
W_{50} : Average weight of a riprap (lb)

- U.S. Geological Survey method (Blodgett 1981)

$$D_{50} = 0.01\ V^{2.44}$$

$$D_{50} = \left[\frac{8 \times W_{50}}{\pi \gamma_s}\right]^{1/3}$$

Where,

V : Average flow velocity (ft/s)
γ_s : Weight of riprap (γ_s=137 lb/ft^3)
D_{50} : Average diameter of a riprap (ft)
W_{50} : Average weight of a riprap (lb)

- USBR 1936

$$D_{50} = (Vb / 3.88)^2$$

$$D_{50} = \left[\frac{8 \times W_{50}}{\pi \gamma_s}\right]^{1/3}$$

Where,

Vb : Near bed velocity at 0.9d (m/s)
γ_s : Weight of riprap (γ_s=2,200 kg/m^3)
D_{50} : Average diameter of a riprap (m)
W_{50} : Average weight of a riprap (kg)

- Osama 1995

$$D_{50} = (Vb / 4.3)^2$$

$$D_{50} = \left[\frac{8 \times W_{50}}{\pi \gamma_s}\right]^{1/3}$$

Where,

Vb	:	Near bed velocity at 0.9d (m/s)
γ_s	:	Weight of riprap (γ_s=2,200 kg/m^3)
D_{50}	:	Average diameter of a riprap (m)
W_{50}	:	Average weight of a riprap (kg)

(2) The flow velocity of formula to determine suitable riprap weight and size

In order to determine the average weight and diameter of riprap, the velocity for riprap design is set as 1.5 to 2.0 times the flow velocity (V), considering the temporary increase in velocity during gate maintenance and variations between calculated and actual flow velocities in each canal.

Table 9-3.1 Flow velocity to determine the suitable riprap weight and scale

	Discharge Qmax (m^3/s)	Flow area A (m^2)	Flow velocity V (m/s)	Velocity for the riprap design (1.5～2.0 V)	Applied
Bahr Yusef	227	151.68	1.50	2.25～3.00	➡2.50
Ibrahimia	186	135.12	1.38	2.07～2.76	➡2.50
Badraman	9	10.00	0.90	1.35～1.80	➡1.50
Diroutiah	12	13.20	0.91	1.37～1.82	➡1.50

(3) Determination of the average riprap weight and diameter

Tables 9-3.2 to 9-3.5 show the results of calculations for each flow velocity utilizing the above four formulae. There are some large differences among the riprap weights as determined by the recommended formula, but the riprap weights and sizes for the bed protection works on the downstream side of the regulators are as follows:

- **Bahr Yusef, Ibrahimia : D_{50} = 0.40 m W_{50} = 60 kg**
- **Badraman, Ditoutiah : D_{50} = 0.20 m W_{50} = 10 kg**

Table 9-3.2 Calculation result by Isbash method (Isbash 1936)

Va		C	γs	γw	D_{50}		W_{50}	
(m/s)	(ft/s)		(lb/ft^3)	(lb/ft^3)	(m)	(ft)	(kg)	(lb)
0.50	1.64	0.86	137	62.5	0.01	0.05	0.00	0.01
1.00	3.28	0.86	137	62.5	0.06	0.19	0.17	0.37
1.50	4.92	0.86	137	62.5	0.13	0.43	1.89	4.17
2.00	6.56	0.86	137	62.5	0.23	0.76	10.64	23.45
2.50	8.20	0.86	137	62.5	0.36	1.18	40.58	89.45
3.00	9.84	0.86	137	62.5	0.52	1.71	121.16	267.11

Table 9-3.3 Calculation result by U.S. Geological Survey method (Blodgett 1981)

Va		γs	D_{50}		W_{50}	
(m/s)	(ft/s)	(lb/ft^3)	(m)	(ft)	(kg)	(lb)
0.50	1.64	137	0.01	0.03	0.00	0.00
1.00	3.28	137	0.06	0.18	0.15	0.32
1.50	4.92	137	0.15	0.49	2.84	6.26
2.00	6.56	137	0.30	0.99	23.32	51.41
2.50	8.20	137	0.52	1.70	119.43	263.30
3.00	9.84	137	0.81	2.65	453.65	1000.14

Table 9-3.4 Calculation result by USBR 1936

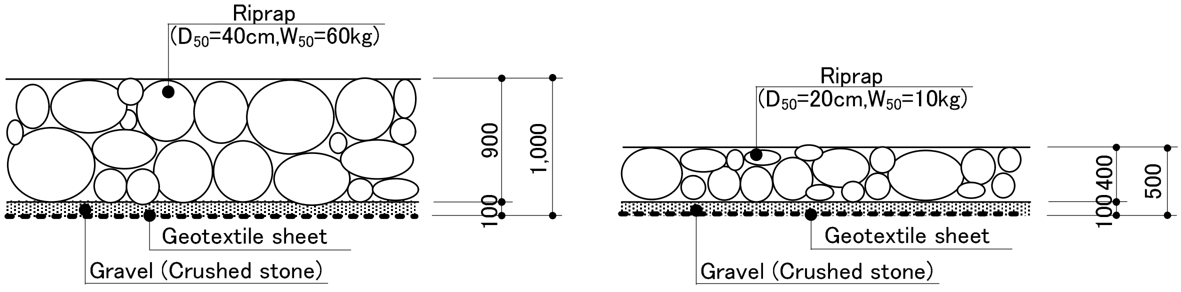
Vb (m/s)	γs (kg/m^3)	D_{50} (m)	W_{50} (kg)
0.50	2,200	0.02	0.00
1.00	2,200	0.07	0.25
1.50	2,200	0.15	2.88
2.00	2,200	0.27	16.20
2.50	2,200	0.42	61.79
3.00	2,200	0.60	184.50

Table 9-3.5 Calculation result by Osama 1995

Vb (m/s)	γs (kg/m^3)	D_{50} (m)	W_{50} (kg)
0.50	2,200	0.01	0.00
1.00	2,200	0.05	0.14
1.50	2,200	0.12	1.56
2.00	2,200	0.22	8.74
2.50	2,200	0.34	33.35
3.00	2,200	0.49	99.58

(4) Design of bed protection

The stone scale and design should be a combination of "Geotextile sheets + stones as filter (0.1~0.2m) + riprap stones (2~3 × D_{50})", which have been approved at the joint 22nd TAC meeting with MMG and DWG. The approved designs are as follows.



New Bahr Yusef Reg. and Ibrahimia Reg.

New Badraman Reg.

Figure 9-3.1Typical section of bed protection

【Reference: Calculations of Stone Gravel Size Distribution】

The compositions of bed protection materials and the purpose of installation are shown in Table 9-3.6.

Table 9-3.6 Compositions of bed materials and purposes of installation

Material	Purpose of Installation	Remarks
Riprap Stone	Installed to protect the dissipation and the local scouring downstream due to the high flow velocity.	Bahr Yusef and Ibrahimia Regulators: D_{50}=40 cm Badraman Regulator: D_{50}=20 cm
Gravel (Crushed stone)	Installed as the cushion material with rubble to prevent the damage of the geotextile sheets.	
Geotextile sheet	Installed to prevent the suction of the present bed materials and control the degradation of the streambed.	
Present streambed material	—	Fine sand D_{15}=0.14 mm, D_{50}=0.23 mm, and D_{85}=0.37 mm

The specifications of the stone materials used for the bed protection works are examined based on the “Standard Gravel Curve” as presented by HRI, Egypt.

The crushed stone installed under the riprap is intended to function as the cushion material. For that crushed stone, the hydraulic specifications are not required.

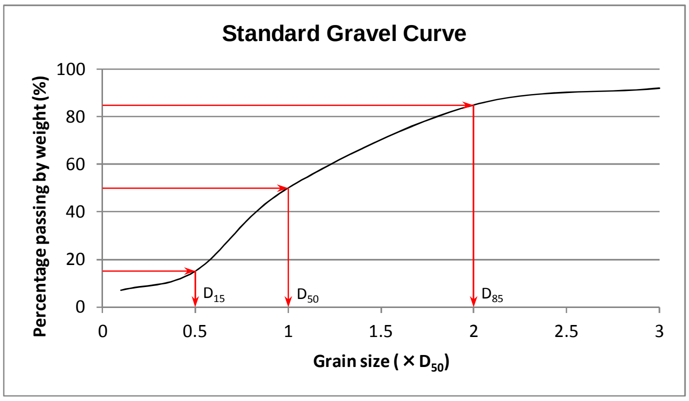


Figure 9-3.2 Standard gravel size distribution of riprap stone (Source: HRI)

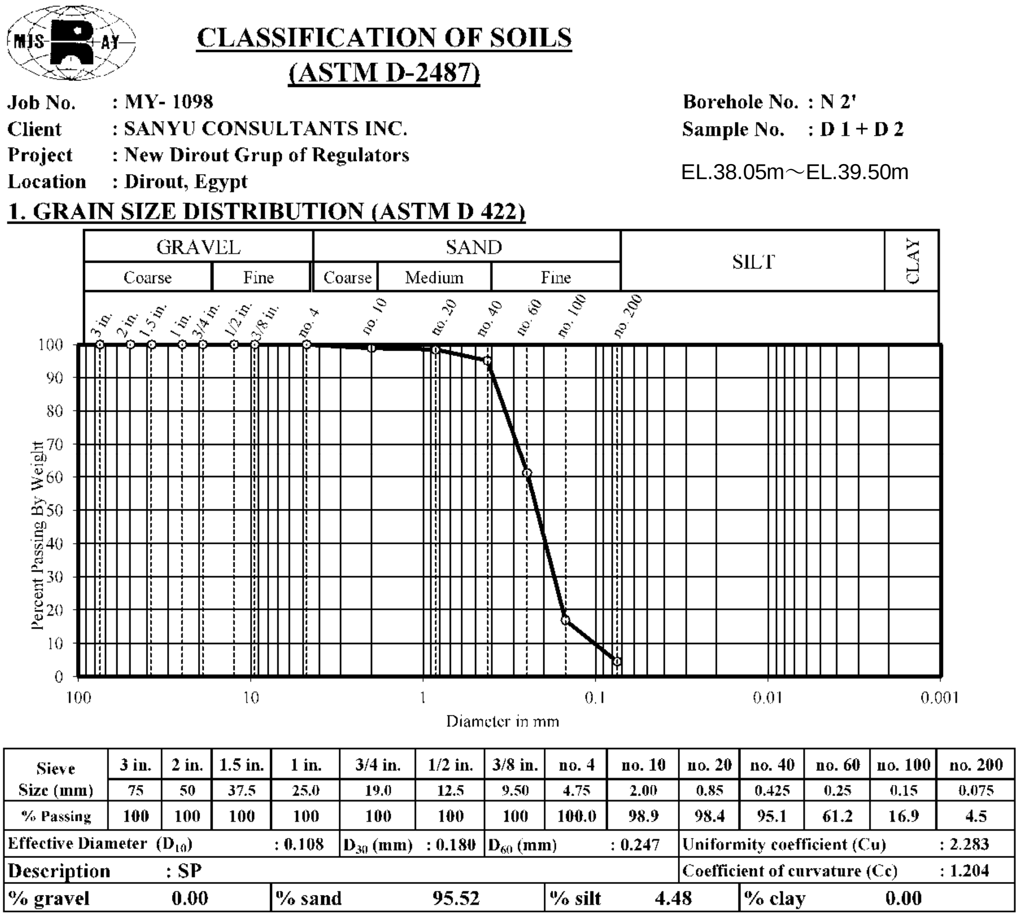
However, the crushed stone is required to have an effective grain size for piping to protect the suction from the riprap stones in order to keep long-term stability. Thus, the crushed stone size specifications should satisfy the following equation:

$$\frac{\text{15\% of grain size of filter material}}{\text{85\% of gravel size of the materials protected by filter}} < 5 \quad \cdots\cdots\cdots \quad \text{(Piping rule)}$$

Table 9-3.7 Grain size distribution for bed protection materials

	New Bahr Yusef Reg. New Ibrahimia Reg.			New Badraman Reg.		
	Riprap	Crushed stone	Remarks	Riprap	Crushed stone	Remarks
D_{15} (=0.5D_{50})	20 cm	1.25 cm	20/5.0=4 < 5 (OK)	10	1.25	10/5.0=2 < 5 (OK)
D_{50}	40 cm	2.5 cm		20	2.5	
D_{85} (=2.0D_{50})	80 cm	5.0 cm		80	5.0	

- Present bed materials under the downstream apron



CLASSIFICATION OF SOILS
(ASTM D-2487)

Job No. : MY- 1098
Client : SANYU CONSULTANTS INC.
Project : New Dirout Grup of Regulators
Location : Dirout, Egypt

Borehole No. : N 2'
Sample No. : D 1 + D 2
EL.38.05m～EL.39.50m

1. GRAIN SIZE DISTRIBUTION (ASTM D 422)

Sieve Size (mm)	3 in.	2 in.	1.5 in.	1 in.	3/4 in.	1/2 in.	3/8 in.	no. 4	no. 10	no. 20	no. 40	no. 60	no. 100	no. 200
	75	50	37.5	25.0	19.0	12.5	9.50	4.75	2.00	0.85	0.425	0.25	0.15	0.075
% Passing	100	100	100	100	100	100	100	100.0	98.9	98.4	95.1	61.2	16.9	4.5

Effective Diameter (D_{10}) : 0.108
D_{30} (mm) : 0.180
D_{60} (mm) : 0.247
Uniformity coefficient (Cu) : 2.283
Description : SP
Coefficient of curvature (Cc) : 1.204
% gravel 0.00
% sand 95.52
% silt 4.48
% clay 0.00

Percent passing by weight	Grain size (mm)		Remarks
15%	D_{15}	0.139	
50%	D_{50}	0.225	
85%	D_{85}	0.373	

10. Design of Pier

10-1Height and thickness of pier

(1) Height of pier

The height of the pier is determined by the bottom elevation and the height of a fully opened gate (EL.4 and h respectively), height of free-board (Fb), and the thickness of the regulator top (t) shown in Table 10-1.1.

Elevation of the pier top EL.5 = the bottom elevation of fully opened gate (EL.4) + the height of fully opened gate(h) + Free board (Fb) + the thickness of the regulator top (t)

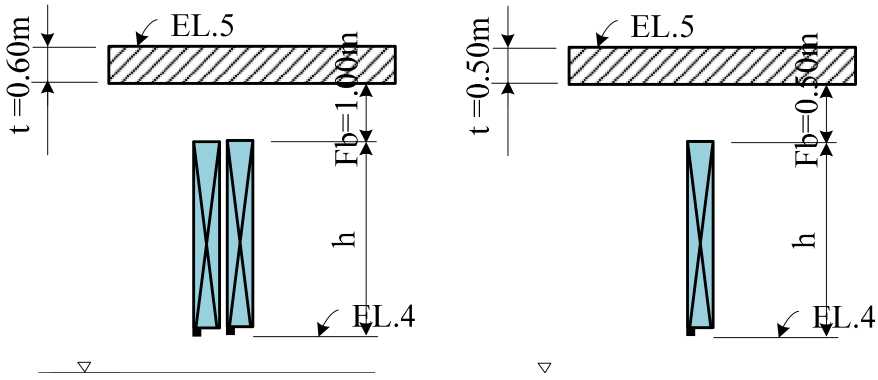
Where, the bottom elevation of fully opened gate (EL.4): refer to 7-3.

Height of fully opened gate (h): lower gate height for the double leaf gate

Free board (Fb): Room for the gate structure (such as spoiler and hook) and free space during reel-up, which is 1.0m for a large scale gate and 0.5m for a small scale gate

Table 10-1.1 Height of pier for each regulator

Regulator	Bottom elevation of the fully open gate: EL.4 (m)	Height of fully open gate: h (m)	Free board: Fb (m)	Thickness of top regulator: t (m)	Elevation of the pier top: EL.5 (m)
Bahr Yusef	47.50	3.40	1.00	0.60	52.50
Ibrahimia	47.50	3.40	1.00	0.60	52.50
Sahelyia	47.50	3.55	0.50	0.50	52.05
Diroutiah	47.50	2.35	0.50	0.50	50.85
Badraman	47.50	2.65	0.50	0.50	51.15
Abo Gabal	47.50	2.95	0.50	0.50	51.45



Large scale (double leaf) gate

Small scale (single leaf) gate

Figure 10-1.1 Schematic drawing of the elevation of the bottom of the fully opened gate (EL.4) and pier top (EL.5)

(2) Thickness of pier

The thickness of the pier should leave enough room for the groove, the transference of the load of the gate onto the pier body, and for ensuring structural stability.

Experiential regulations from the Egyptian Code “Vol.3. Chap.5 Regulators and Gates,” require 1/4 to 1/3 of the vent width. Moreover, another experiential formula is shown below from the textbook *Part No.2 Design of Hydraulic Structures Spillways Regulators Barrage*.

$tp = (0,25〜0.35) \times S \geqq 1.00m$

where, tp: Thickness of the pier (m) *Minimum pier thickness is 1.00m
S: Vent width (m)

Thickness of the piers for large scale regulators (Bahr Yusef and Ibrahimia) and small scale regulators (Sahelyia, Badraman, and Abo Gabal) is calculated as follows.

Large scale regulators S=6.00m: tp = (0.25〜0.35) ×6.00 = 1.50m〜2.10m

Small scale regulators S=2.00m: tp = (0.25〜0.35) ×2.00 = 0.50m〜0.70m ⇒ tp = 1.00m

Regarding the gate (double roller gate with hydraulic cylinder) for large scale regulators, the guide wall is not designed to reduce the height of piers. In this case, larger room (2.40m×0.85m) is required for the blockout.

Therefore, pier thickness for the large scale regulators is calculated as follows.

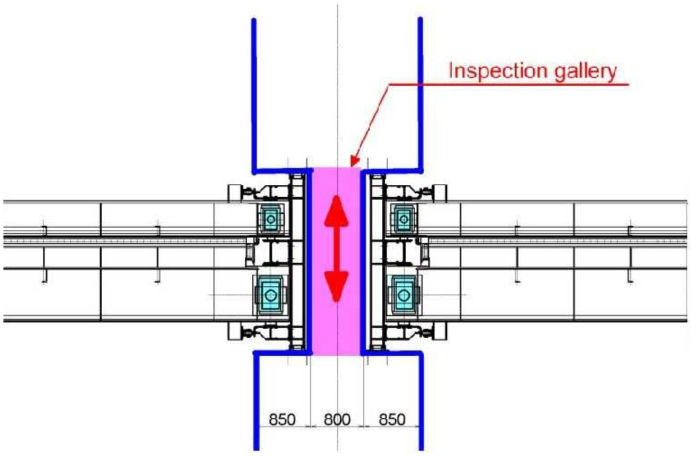


Figure 10-1.2 Schematic drawing for pier width

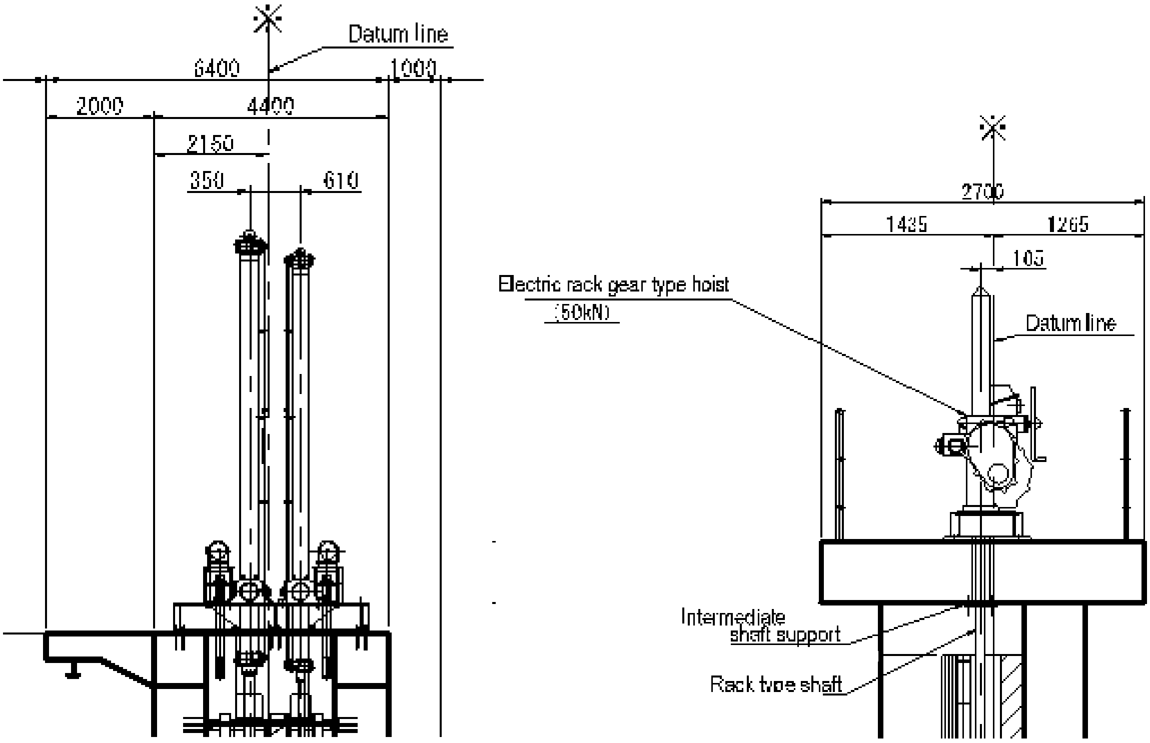
tp = 0.85m (blockout for the groove)×2＋0.80m（effective pier material width and gallery）
= 2.50m)

Thus, the thickness of the piers is 2.50m for large scale regulators and 1.00m for small scale regulators.

10-2 Design of the superstructure of pier

Operation space is designed on top of the piers, taking into account space for a rack which lifts/lowers gate, as well as space for conducting inspections. For large scale regulators (New Bahr Yusef and Ibrahimia), clearance for gate extraction was designed with the base frame of the hydraulic cylinder. In addition, a rail for the hoist crane was designed.

The superstructure of the piers (operation space) is shown in Figure 10-2.1.



Gate for large regulators (double leaf)

Gate for small regulators (single leaf)

Figure 10-2.1 Schematic drawing of the top of pier (operation space)

11. Stability and Structural Calculation

NGDRs are divided by regulator size into two groups:

- ✓ Large scale regulators: Bahr Yusef regulator and Ibrahimia regulator.
- ✓ Small scale regulators: Badraman regulator, Abo Gabal regulator, and Sahelyia regulator.

There are no specific and integrated descriptions of how to examine the regulator stability in the Egyptian code. Accordingly, the Japanese standard method should basically be applied. However, the fundamental conditions of the stability analysis i.g., safety ratio, soil density and other materials density, should apply the value provided by the Egyptian side in the WG meeting. In addition, the analysis case of the maintenance conditions approved by the Egyptian are applied.

11-1 Examination of stability for the large scale regulators

(1) Examination case

When examining regulator stability, the following should be taken into consideration:(1) the situation of the gate, (2) water level at U.S. and D.S., (3) normal and seismic situation, and so on. Bahr Yusef and Ibrahimia regulators are of the same structural size, so the examination mode is also the same.

Table11-1.1 Conditions of stability analysis for the large scale regulators

Case	Condition	Direction	Water Level			Gate situation	Additional condition
Case1	Normal	Long.	U.S.	WL47.00m	HWL	Open gate	—
			D.S.	WL47.00m	HWL		
Case2	Normal	Long.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case3	Normal	Long.	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case4	Normal	Lateral.	U.S.	WL46.55m	Max.WL	Open gate	—
			D.S.	WL46.55m	Max.WL		
Case5	Normal	Lateral.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case6	Normal	Lateral.	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case7	Seismic	Long.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case8	Seismic	Long	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case9	Seismic	Lateral.	U.S.	WL46.55m	Max.WL	Open gate	—
			D.S.	WL46.55m	Max.WL		
Case10	Seismic	Lateral.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case11	Seismic	Lateral.	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case12	Seismic	Long.	U.S.	WL46.55m	Max.WL	Open gate	—
			D.S.	WL46.55m	Max.WL		
Case13	Normal (Maintenance)	Long.	U.S.	WL46.55m	Max.WL	Maintenance gate	—
			D.S.	WL45.82,45.13m	Low		

※Maximum operation water level at U.S. is same as head level of gate (WL46.30 + 0.25m＝EL46.55) forsecurity

※At fully closed gate situation, water level at D.S. is same as apron level（EL39.5）.

(2) Necessary safety ratio and inspected items

Table11-1-2 Inspection items for stability analysis

Inspection items	Safety ratio	
	Normal	Seismic
Note1) For land slide	Fs >1.5	Fs >1.15
Note1) For Fall down	e < B/6 (B; width for direction of examination)	e < B/3 (B; width for direction of examination)
Note2) For bearing capacity	Q <Qa	Q <Qa'

Note1: Provided by Egyptian side
Note2: Bearing capacity is examined at "12 Foundation Works for Regulator"

(3) Conditions of loaded weight

1) Unit density

Table11-1.3 Bulk density

	(kN/m^3)		(kN/m^3)
Rein-forced concrete（γrc）	25	Saturated soil（γs）	20
Concrete（γc）.	23	Submerged soil（γs'）	10
Wet soil（γs）	18	Water（γw）	10

2) Earth pressure

Table11-1.4 Coefficient of earth pressure

	Normal	Seismic	Seismic（submerged）	Sedimentation
Friction on wall	0°	0°	0°	－
Active co-e. EP	0.333	0.383	0.390	0.5
Passive co-e. EP.	3.000	2.784	2.858	－

Internal friction : φ= 30°

3) Gate weight

It is shown in Table 11-1.5. The weight for stoplogs is approximated as 2/3 of the leaf gate weight.

Table11-1.5 Gate weight

Regulator	item	Spec.			vents	(kN)/vent	
		width (m)	height (m)	electric power (kw)			
Bahr Yusef regulator Ibrahimia regulator	Upper leaf	6.00	3.15	11.0	4	66	173
	Lower leaf	6.00	3.40	11.0	4	107	
	Grooves	－	－	－	4	163	389
	Hoist	Hydraulic pressure type			4	226note)	
	Total					562	
Stop-log	224kN/vent*						

*Note: Weight of hoist includes weight of operation deck

4) Bridge weight

Table11-1.6 Bridge weight

Regulator	Loading case		Normal	Seismic
Bahr Yusef regulator Ibrahimia regulator	dead load	(kN/vent)	1752	1752
	dead load＋live load	(kN/vent)	2472	－
	wind pressure	(kN/vent)	83	－
	horizontal force by seism.	(kN)	－	59

5) Wind pressure

w= 3.0 (kN/m^2) [Co-efficient by type: plane surface: 1.20] [curve surface: 0.70]

6) Other weight ;

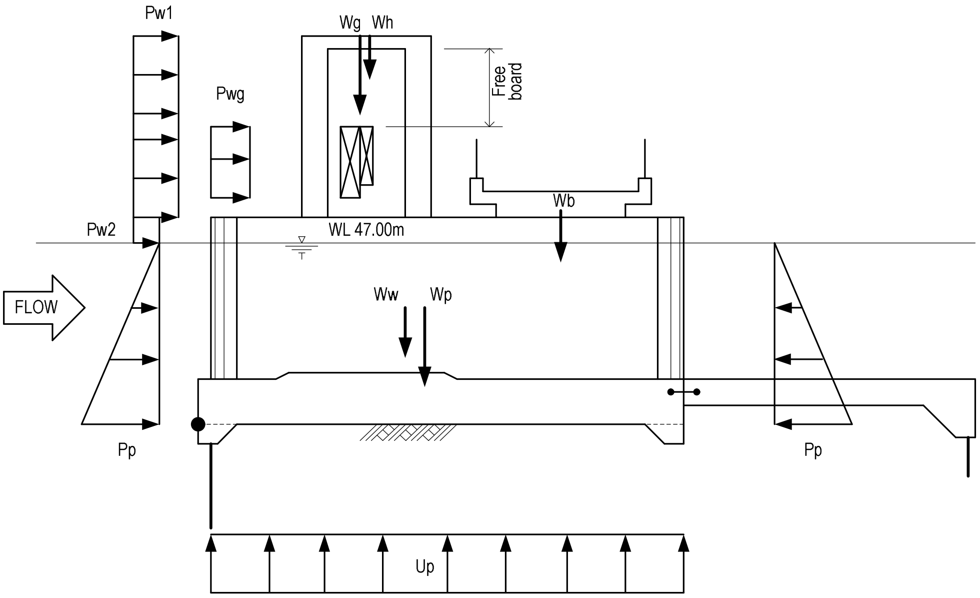
Vehicle: qv= 10.0 (kN/m^2) Pedestrian: qp= 5.0 (kN/m^2)

7) Up-lift coefficient ; μ = 1.0

8) Combination of loaded weight

The combination of loaded weight is shown on Figure 11-1.1to Figure 11-1.7. **The regulator is designed as one slab structure, which means no expansion and contraction joint is designed in the slab of regulator foundation.** The table shows the section of each regulator pier between the abutment and middle of the pier to clarify the loaded weight and then examine stability.

【CASE 1： Regular / Longitudinal direction/ H.H.W.L. / Full OP】



【CASE 2：Regular / Longitudinal direction/ H.WL+0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

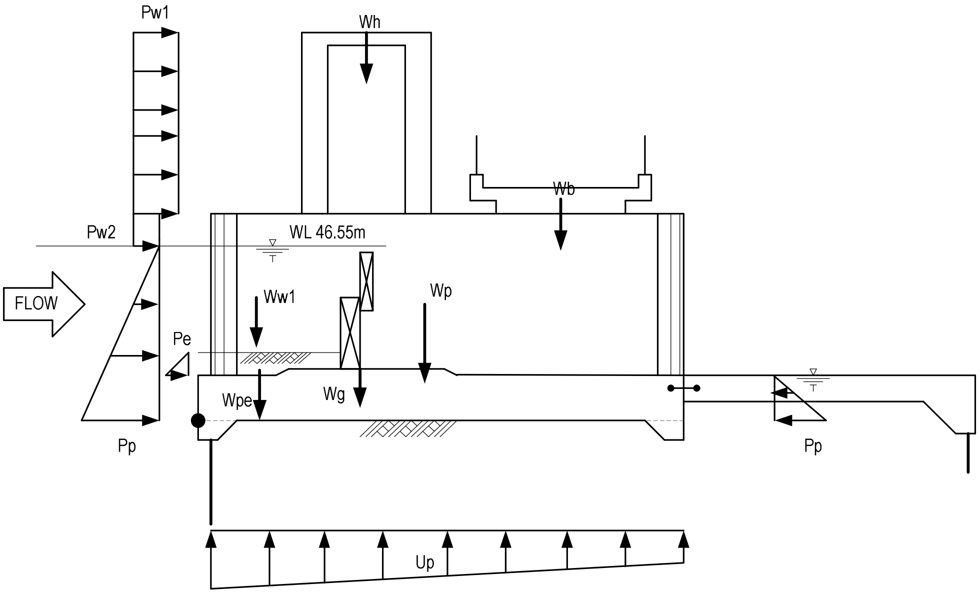
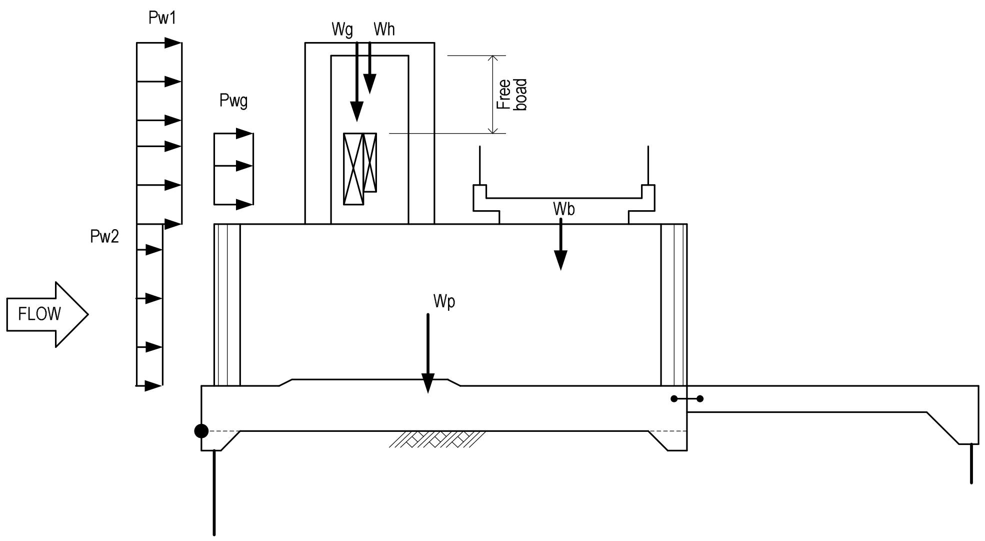


Figure 11-1.1 Load condition for regulator (case 1, 2)

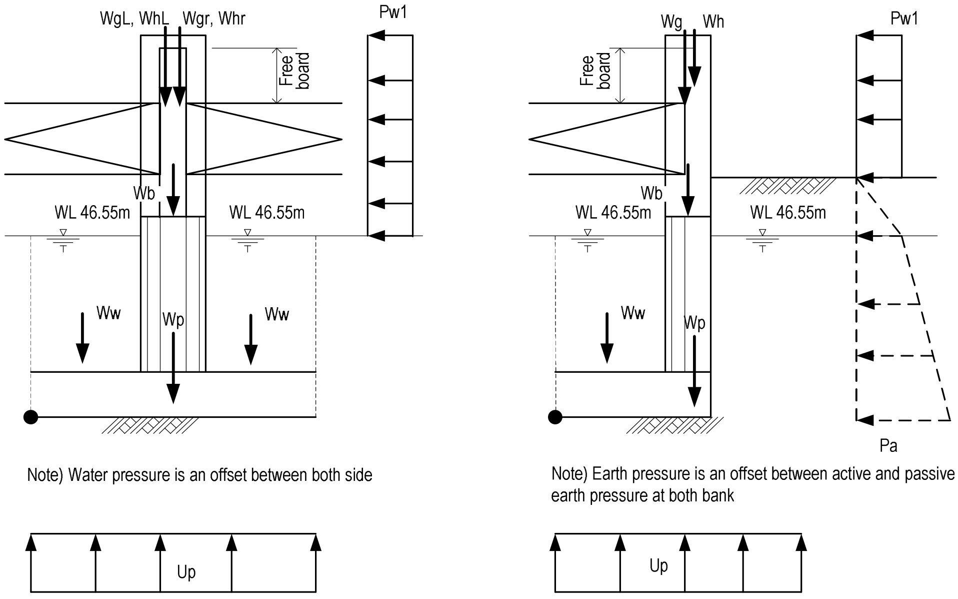
【CASE 3：Regular / Longitudinal direction/ No. water / Full OP】



【CASE 4：Regular / Lateral direction / H.W.L. +0.25m water level / Full OP】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

Middle pier　　Abut pier



Note) Water pressure is an offset between both side

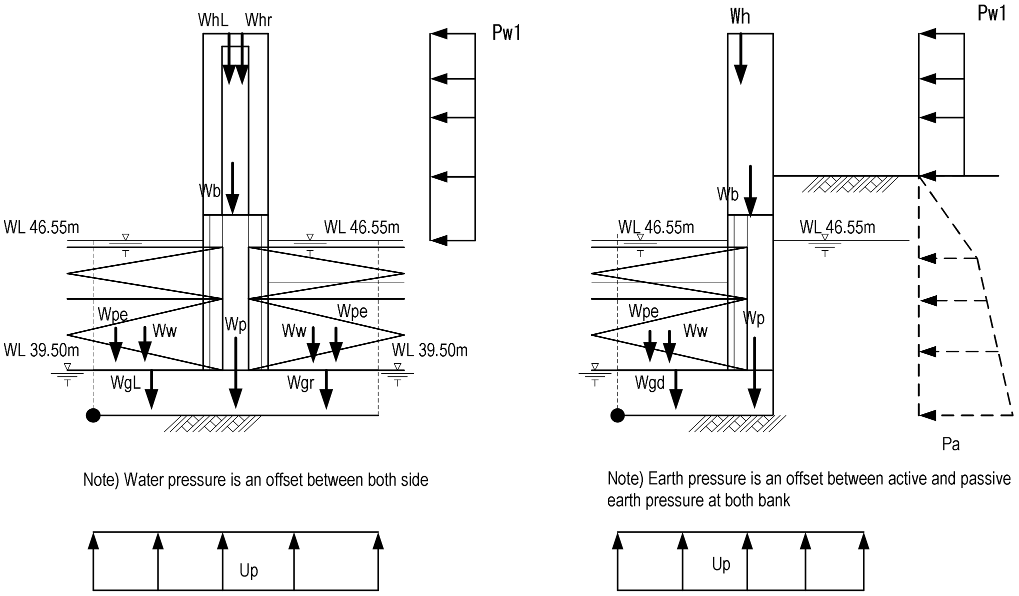
Note) Earth pressure is an offset between active and passive earth pressure at both bank

Figure 11-1.2 Load condition for regulator (case 3, 4)

【CASE 5 : Regular / Lateral direction/ H.W.L.+0.25m water level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

Middle pier Abut pier

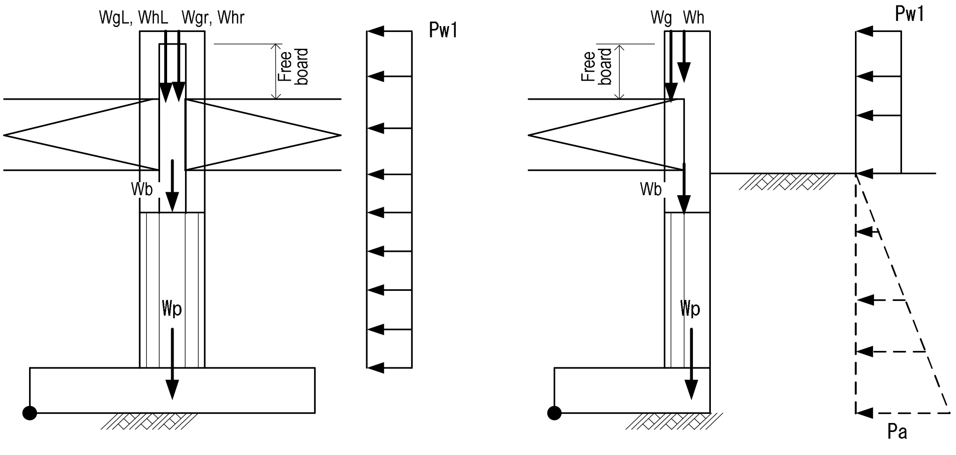


Note) Water pressure is an offset between both side

Note) Earth pressure is an offset between active and passive earth pressure at both bank

【CASE 6 : Regular / Lateral direction / No water / Full OP】

Middle pier Abut pier



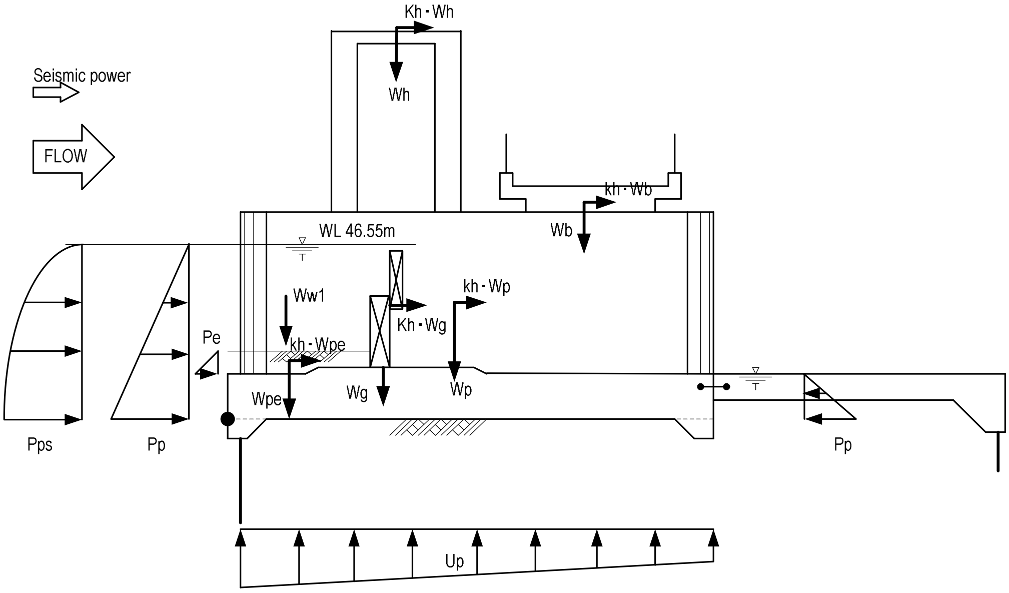
Note) Water pressure is an offset between both side

Note) Earth pressure is an offset between active and passive earth pressure at both bank

Figure 11-1.3 Load condition for regulator (case 5, 6)

【CASE 7 : Seism / Longitudinal direction / H.W.L. +0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC



【CASE 8 : Seism / Longitudinal direction / No water / Full OP】

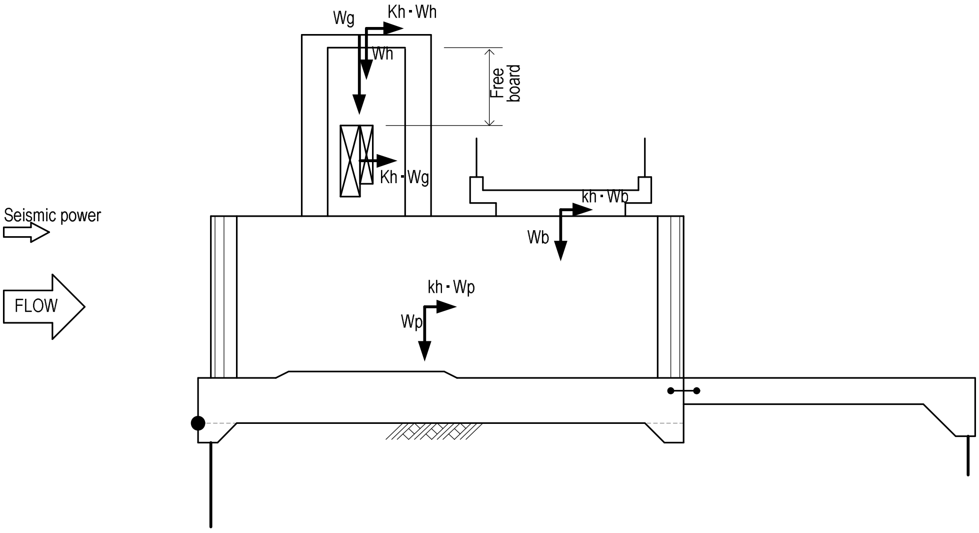
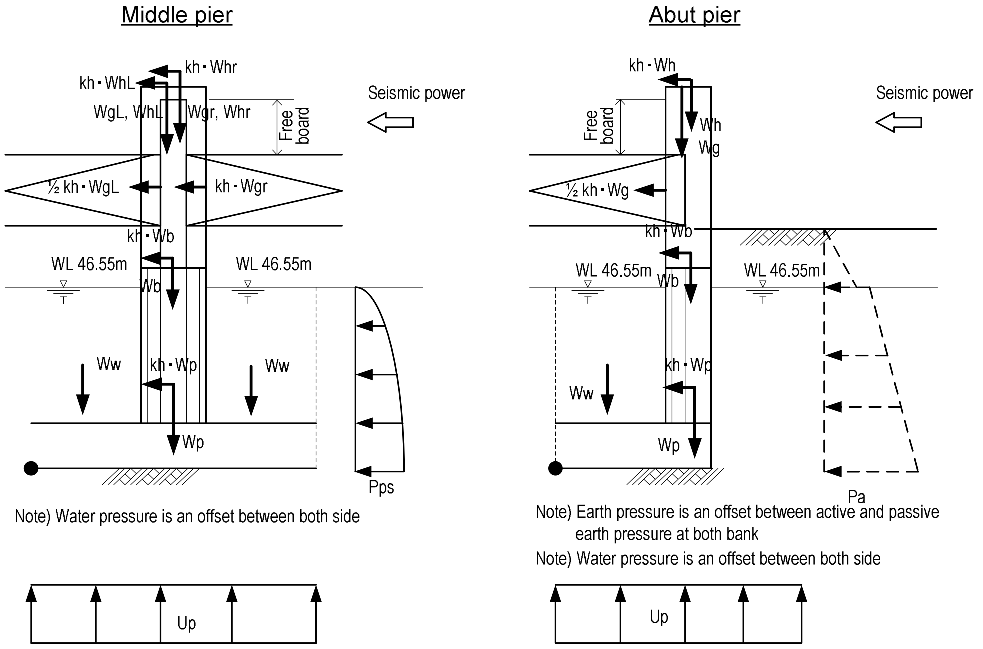


Figure 11-1.4 Load condition for regulator (case 7, 8)

【CASE 9 : Seism / Lateral direction / H.W.L + 0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC



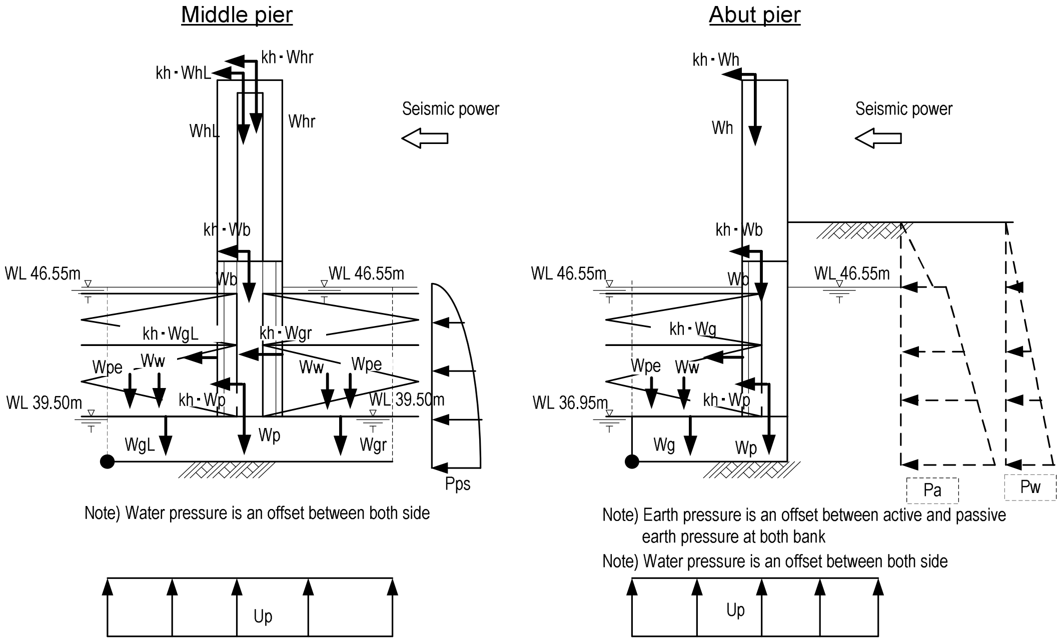
Note) Water pressure is an offset between both side

Note) Earth pressure is an offset between active and passive earth pressure at both bank

Note) Water pressure is an offset between both side

【CASE 10 : Seism / Lateral direction / H.W.L + 0.25m level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC



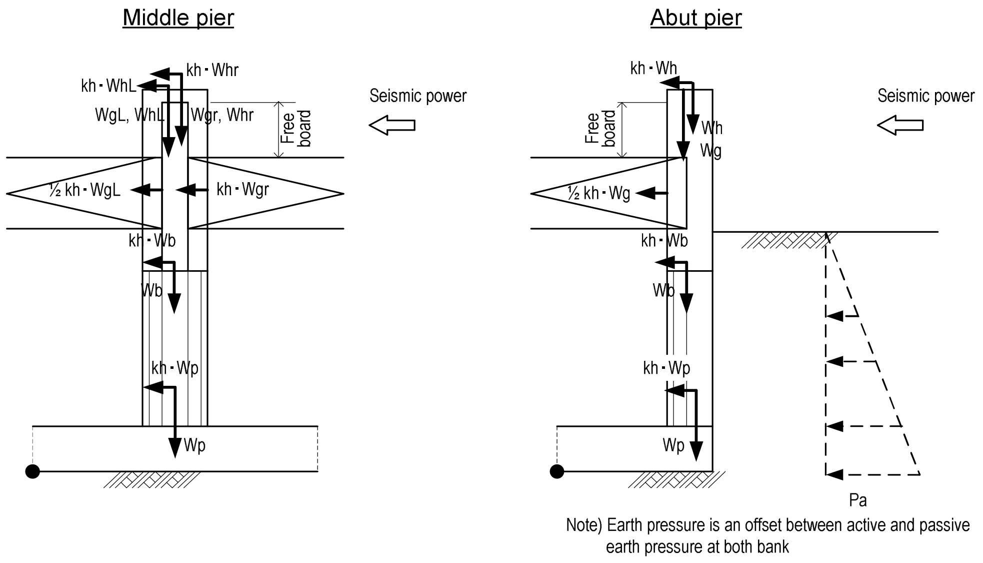
Note) Water pressure is an offset between both side

Note) Earth pressure is an offset between active and passive earth pressure at both bank

Note) Water pressure is an offset between both side

Figure 11-1.5 Load condition for regulator (case 9, 10)

【CASE 11：Seism / Lateral direction / No water / Full OP】



Middle pier

Abut pier

Note) Earth pressure is an offset between active and passive earth pressure at both bank

【CASE 12：Seism / Longitudinal direction/ H.W.L.+0.25m water level / Full OP】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

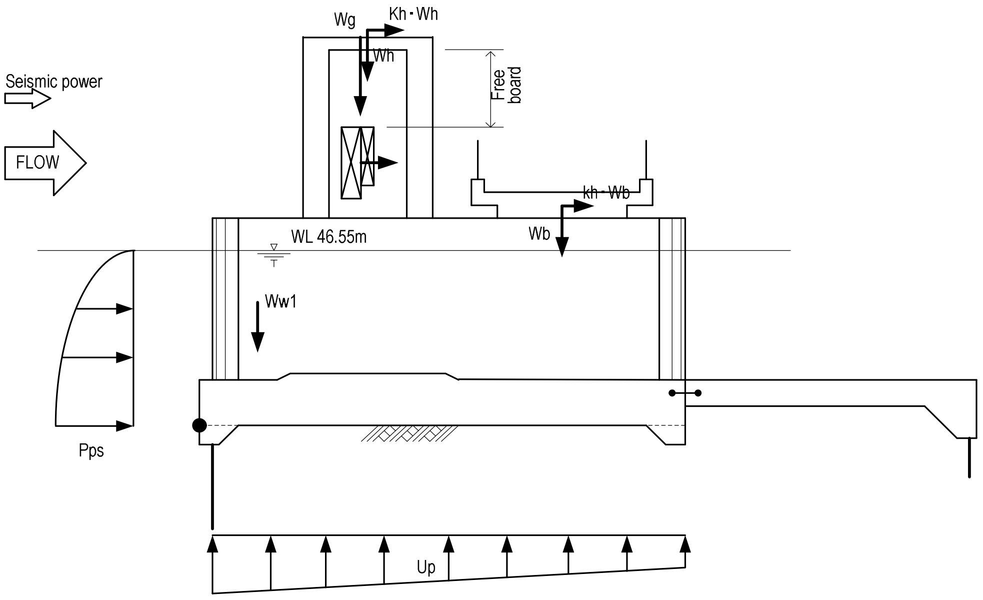


Figure 11-1.6 Load condition for regulator (case 11, 12)

【CASE 13： / Regular / Longitudinal direction/ H.W.L.+0.25m water level / Maintenance case】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

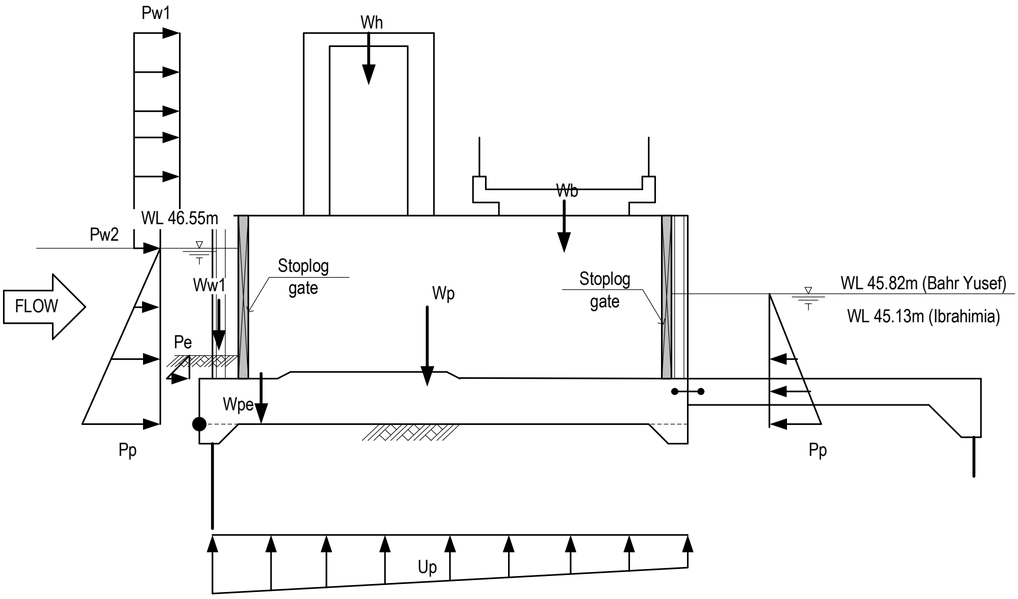


Figure 11-1.7 Load condition for regulator (case 13)

(4) Result of examination of stability of large scale regulators

As shown on Table 11-1.7, each regulator meets necessary stability safety requirements. The examination of bearing capacity is studied below in chapter 12, ‘Design of Foundation Works. As a result of the stability examination, the vertical force was found to be far heavier than the horizontal force; therefore, negative eccentricity force is not observed at the targeted regulators. The results are applicable to both regulators because they are both the same structural size.

Table11-1.7 Summary of the stability analysis (Bahr Yusef and Ibrahimia regulators)

Summary table of result on the stability examination for Bahr Yusef and Ibrahimia Regulator

Pier	Case	Direction	Condition	Vertical force	Resistant moment	Horizontal force	Torque moment	For the sliding			For the fall down			note1) For the ground reaction			Judge	Remarks
				V	V･x	H	H･y	Safe ratio			Eccentricity		B/6 (Allowable)	Ground reaction	Ground reaction	Bearing		
				(kN)	(kN･m)	(kN)	(kN･m)	Required ratio		Desing	e（m）			Q1 (kN/m2)	Q2 (kN/m2)	(kN/m2)		
Bhar Yusef and Ibrahimia Regulator	1	Long.	Regular	91,358.69	1,220,699.63	883.93	9,863.23	1.50	≦	62.01	-0.48	≦	4.65	82.72	101.76		OK	
	2	Long.	Regular	88,729.08	1,141,261.14	14,388.83	42,991.19	1.50	≦	3.70	-0.60	≦	4.65	78.03	101.14		OK	
	3	Long.	Regular	134,758.39	1,829,038.99	987.46	9,781.09	1.50	≦	81.88	-0.30	≦	4.65	127.28	144.84		OK	
	4	Lateral.	Regular	90,408.54	1,604,751.58	724.42	7,830.98	1.50	≦	74.88	0.09	≦	5.92	92.67	89.89		OK	
	5	Lateral.	Regular	88,729.08	1,574,941.17	1,777.68	17,865.68	1.50	≦	29.95	0.20	≦	5.92	92.61	86.56		OK	
	6	Lateral.	Regular	134,758.39	2,391,961.42	2,506.86	16,645.55	1.50	≦	32.25	0.12	≦	5.92	138.82	133.30		OK	
	7	Long.	Seism	85,846.08	1,093,259.19	25,761.42	91,358.30	1.15	≦	2.00	-0.15	≦	9.30	83.88	89.47		OK	
	8	Long.	Seism	131,875.39	1,788,821.14	10,550.03	50,299.11	1.15	≦	7.50	0.00	≦	9.30	133.15	133.15		OK	
	9	Lateral.	Seism	87,525.54	1,553,578.33	14,202.59	68,505.54	1.15	≦	3.70	0.78	≦	11.83	100.02	76.72		OK	
	10	Lateral.	Seism	85,846.08	1,523,767.92	11,091.17	52,615.99	1.15	≦	4.64	0.61	≦	11.83	95.61	77.74		OK	
	11	Lateral.	Seism	131,875.39	2,340,788.17	10,550.03	50,299.11	1.15	≦	7.50	0.38	≦	11.83	141.70	124.60		OK	
	12	Long.	Seism	89,965.54	1,194,735.08	10,909.75	54,140.20	1.15	≦	4.95	-0.07	≦	9.30	89.47	92.20		OK	
	13	Long.	Regular	80,093.13	1,187,305.92	2,811.86	9,431.98	1.50	≦	17.09	0.99	≦	4.65	98.08	63.65		OK	Bahr Yusef
	13	Long.	Regular	80,819.68	1,181,724.85	4,765.33	17,219.80	1.50	≦	10.18	0.88	≦	4.65	97.04	66.16		OK	Ibrahimia

Note 1) Ground reaction for the bearing capacity should be consideration in Chapter 12

11-2 Examination of stability of the small scale regulators

(1) Examination case

Examination of stability for regulator should take the situation of gate, water level at U.S. and D.S., normal and seismic situation, etc. into consideration. The targeted small scale regulators are: Badraman regulator (Badraman and Diroutiah canal), Abo Gabal regulator (Abo Gabal and Irad Delgaw canal), and Sahelyia (Sahelyia canal).

Table11-2.1 Conditions of stability analysis for the small scale regulators

Case	Condition	Direction	Water Level			Gate situation	Additional condition
Case1	Normal	Long.	U.S.	WL47.00m	HWL	Open gate	－
			D.S.	WL47.00m	HWL		
Case2	Normal	Long.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	Bad.CL :WL43.40m Dai.CL :WL43.70m Abo.Irad CL. :WL44.15m Sahe.CL :WL44.65m	Low		
Case3	Normal	Long.	U.S.	－	No WL	Open gate	－
			D.S.	－	No WL		
Case4	Normal	Lateral.	U.S.	WL46.55m	Max.WL	Open gate	－
			D.S.	WL46.55m	Max.WL		
Case5	Normal	Lateral	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	Bad.CL :WL43.40m Dai.CL :WL43.70m Abo.Irad CL. :WL44.15m Sahe.CL:WL44.65m	Low		
Case6	Normal	Lateral.	U.S.	－	No WL	Open gate	－
			D.S.	－	No WL		
Case7	Seism.	Long.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	Bad.CL :WL43.40m Dai.CL :WL43.70m Abo.Irad CL. :WL44.15m Sahe.CL :WL44.65m	Low		
Case8	Seism.	Long.	U.S.	－	No WL	Open gate	－
			D.S.	－	No WL		
Case9	Seism.	Lateral	U.S.	WL46.55m	Max.WL	Open gate	－
			D.S.	WL46.55m	Max.WL		
Case10	Seism.	Lateral.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	Bad.CL :WL43.40m Dai.CL :WL43.70m Abo.Irad CL. :WL44.15m Sahe.CL:WL44.65m	Low		
Case11	Seism.	Lateral.	U.S.	－	No WL	Open gate	－
			D.S.	－	No WL		
Case12	Seism.	Long.	U.S.	WL46.55m	Max.WL	Open gate	－
			D.S.	WL46.55m	Max.WL		
Case13	Normal (Maintenance)	Long.	U.S.	WL46.55m	Max.WL	Maintenance gate	－
			D.S.	Bad.CL :WL45.90m Dai.CL :WL45.90m Abo.Irad CL. :WL45.90m Sahe.CL :WL45.90m	Low		

※Maximum operation water level at U.S. is same as head level of gate (WL46.30 + 0.25m＝EL46.55) for safety
※At fully closed gate situation, water level at D.S. is same as apron level (EL39.5).

(2) Necessary safety ratio and inspected items

Table11-2.2 Inspection items for stability analysis

Inspection items	Safety Ratio	
	Normal	Seismic
Note1) For land slide	Fs >1.5	Fs >1.15
Note1) For Fall down	e < B/6 (B; width for direction of examination)	e < B/3 (B; width for direction of examination)
Note2) For bearing capacity	Q <Qa	Q <Qa'

Note1: Number is provided by Egyptian side
Note2: Bearing capacity is examined in chapter 12, ‘Design of Foundation Works.’

(3) Conditions of loaded weight

1) Unit density

Necessary unit weight for the examination is same as 11-1.(3) 1).

2) Earth pressure

Applied co-efficient earth pressure is same as 11-1.(3) 2).

3) Gate weight

It is shown in Table 11-2.3. The weight for stoplogs are approximated as 2/3 the weight of the leaf gate.

Table11-2.3 Gate weight

Regulator	item	Spec.			vents	(kN)/vent
		width (m)	height (m)	electric power (kw)		
Badraman regulator for Badraman canal	Upper leaf	2.00	2.65	0.65	2	9
	Groove	─	─	─	2	7
	Hoist	Rack gear type by electricity			2	17
	total					33
Stop-log	9kN/vent					
Badraman regulator for Diroutiah canal	Upper leaf	2.00	2.35	0.65	3	8
	Groove	─	─	─	3	7
	Hoist	Rack gear type by electricity			3	17
	total					32
Stop-log	8kN/vent					
Abo Gabal regulator	Upper leaf	2.00	2.40	0.65	4	10
	Groove	─	─	─	4	8
	Hoist	Rack gear type by electricity			4	21
	total					39
Stop-log	10kN/vent					
Sahelyia regulator	Upper leaf	2.00	1.90	0.40	2	12
	Groove	─	─	─	2	9
	Hoist	Rack gear type by electricity			2	26
	total					47
Stop-log	9kN/vent					

4) Bridge weight

The bridge over the Abo Gabal and Sahelyia regulator is of the concrete slab type which is integrated with the regulator body, so should be included in the weight of the regulator body.

Table11-2.4 Bridge weight

Regulator	Loading case		Normal	Seismic
Badraman regulator	dead load	(kN/vent)	509	509
	dead load＋live load	(kN/vent)	1257	─
	wind pressure	(kN/vent)	18	─
	horizontal force by seism.	(kN)	─	40
Diroutiah regulator	dead load	(kN/vent)	509	509
	dead load＋live load	(kN/vent)	1057	─
	wind pressure	(kN/vent)	18	─
	horizontal force by seism.	(kN)	─	40

5) Wind pressure (same as 11-1. (3) 5))

w= 3.0 (kN/m^2) [Co-efficient by type: plane surface: 1.20] [curve surface: 0.70]

6) Other load weight (same as 11-1. (3) 6))

Vehicle: qv= 10.0 (kN/m^2) Pedestrian: qp=5.0 (kN/m^2)

7) Up-lift coefficient ; μ = 1.0 (same as 11-1. (3) 7))

8) Combination of loaded weight

The combination of loaded weight is the same from Figure 11-1.1to Figure 11-1.7. The regulator is designed as one slab structure, which means it is not designed with expansion and contraction joints in the regulator foundation slab. The table shows the section of each regulator pier between the abutment and middle of the pier to clarify the loaded weight and then examine stability.

(4) Result of examination of stability of small scale regulators

As shown in Tables11-2.5to11-2.7, each regulator meets necessary safety requirements. The examination of bearing capacity is studied in Chapter 12, “Foundation Works for Regulators”. The stability examination shows that the vertical force is far heavier than horizontal force, therefore, negative eccentricity force is not observed in the targeted regulators. The results are applicable to both regulators because they are both the same structural size.

Table11-2.5 Summary of the stability analysis at the Badraman regulator
(Badraman and Diroutiah canal)

Summary table of result on the stability examination for Badraman Regulator in Badraman canal

Pier	Case	Direction	Condition	Vertical force	Resistant moment	Horizontal force	Torque moment	For the sliding			For the fall down			note1)For the ground reaction			Judge	Remarks
				V	V·x	H	H·y	Safe ratio			Eccentricity		B/6	Ground reaction	Ground reaction	Bearing		
				(kN)	(kN·m)	(kN)	(kN·m)	Required ratio		Desing	e（m）		(Allowable)	Q1 (kN/m2)	Q2 (kN/m2)	(kN/m2)		
Badraman Regulator in Badraman canal	1	Long.	Regular	13,430.09	178,984.42	104.09	717.19	1.50	≦	77.41	-0.72	≦	4.70	57.61	78.46		OK	
	2	Long.	Regular	14,503.18	198,871.00	756.63	1,496.07	1.50	≦	11.50	-0.28	≦	4.70	69.09	77.85		OK	
	3	Long.	Regular	19,551.97	267,435.44	112.37	682.94	1.50	≦	104.40	-0.39	≦	4.70	90.83	107.27		OK	
	4	Lateral.	Regular	13,758.58	48,155.04	328.56	1,787.37	1.50	≦	25.13	0.13	≦	1.17	77.47	61.93		OK	
	5	Lateral.	Regular	14,503.18	50,761.13	858.16	4,505.34	1.50	≦	10.14	0.31	≦	1.17	92.99	53.95		OK	
	6	Lateral.	Regular	19,551.97	68,431.90	421.82	1,615.57	1.50	≦	27.81	0.08	≦	1.17	105.84	92.26		OK	
	7	Long.	Seism	13,006.18	178,736.35	2,198.20	4,747.79	1.15	≦	3.55	0.01	≦	9.40	66.03	65.75		OK	
	8	Long.	Seism	18,054.97	246,327.74	1,444.40	3,637.76	1.15	≦	7.50	-0.26	≦	9.40	86.40	96.52		OK	
	9	Lateral.	Seism	12,261.58	42,915.54	2,025.88	5,283.23	1.15	≦	3.63	0.43	≦	2.33	85.01	39.22		OK	
	10	Lateral.	Seism	13,006.18	45,521.63	1,490.28	3,760.28	1.15	≦	5.24	0.29	≦	2.33	82.27	49.51		OK	
	11	Lateral.	Seism	18,054.97	63,192.40	1,444.40	3,637.76	1.15	≦	7.50	0.20	≦	2.33	107.14	75.78		OK	
	12	Long.	Seism	12,319.58	164,463.54	1,471.21	3,721.86	1.15	≦	5.02	-0.45	≦	9.40	56.43	68.38		OK	
	13	Long.	Regular	12,656.70	185,830.14	550.38	1,193.45	1.50	≦	13.80	0.68	≦	4.70	73.39	54.84		OK	

Note 1) Ground reaction for the bearing capacity should be consideration in Chapter 12

Summary table of result on the stability examination for Badraman Regulator in Diroutiah canal

Pier	Case	Direction	Condition	Vertical force	Resistant moment	Horizontal force	Torque moment	For the sliding			For the fall down			note1)For the ground reaction			Judge	Remarks
				V	V·x	H	H·y	Safe ratio			Eccentricity		B/6	Ground reaction	Ground reaction	Bearing		
				(kN)	(kN·m)	(kN)	(kN·m)	Required ratio		Desing	e（m）		(Allowable)	Q1 (kN/m2)	Q2 (kN/m2)	(kN/m2)		
Badraman Regulator in Diroutiah canal	1	Long.	Regular	17,457.71	226,559.63	143.26	947.66	1.50	≦	73.12	-0.82	≦	4.62	51.83	74.22		OK	
	2	Long.	Regular	18,666.57	249,465.22	944.36	1,737.70	1.50	≦	11.86	-0.39	≦	4.62	61.70	73.08		OK	
	3	Long.	Regular	25,481.45	339,837.04	152.98	901.14	1.50	≦	99.94	-0.48	≦	4.62	82.43	101.56		OK	
	4	Lateral.	Regular	17,904.87	89,524.35	428.96	2,204.85	1.50	≦	25.04	0.12	≦	1.67	69.29	59.98		OK	
	5	Lateral.	Regular	18,666.57	93,332.85	897.86	4,471.34	1.50	≦	12.47	0.24	≦	1.67	77.09	57.68		OK	
	6	Lateral.	Regular	25,481.45	127,407.25	763.28	2,785.97	1.50	≦	20.03	0.11	≦	1.67	98.06	85.92		OK	
	7	Long.	Seism	17,021.07	227,333.25	2,835.85	5,811.79	1.15	≦	3.60	-0.15	≦	9.23	59.45	63.44		OK	
	8	Long.	Seism	23,835.95	317,046.87	1,906.87	4,620.87	1.15	≦	7.50	-0.35	≦	9.23	79.53	92.57		OK	
	9	Lateral.	Seism	16,259.37	81,296.85	2,799.11	7,039.36	1.15	≦	3.49	0.43	≦	3.33	73.84	43.55		OK	
	10	Lateral.	Seism	17,021.07	85,105.35	1,958.83	4,752.73	1.15	≦	5.21	0.28	≦	3.33	71.77	51.12		OK	
	11	Lateral.	Seism	23,835.95	119,179.75	1,906.87	4,620.87	1.15	≦	7.50	0.19	≦	3.33	95.86	76.24		OK	
	12	Long.	Seism	16,322.37	211,761.19	1,933.29	4,704.88	1.15	≦	5.07	-0.59	≦	9.23	51.39	66.46		OK	
	13	Long.	Regular	17,020.59	235,905.48	601.16	1,265.34	1.50	≦	16.99	0.08	≦	4.62	62.51	60.38		OK	

Note 1) Ground reaction for the bearing capacity should be consideration in Chapter 12

Table11-2.6 Summary of stability analysis (Abo Gabal regulator)

Summary table of result on the stability examination for Abo Gabal Regulator

Pier	Case	Direction	Condition	Vertical force	Resistant moment	Horizontal force	Torque moment	For the sliding			For the fall down			note1)For the ground reaction			Judge	Remarks
				V	V・x	H	H・y	Safe ratio			Eccentricity		B/6	Ground reaction	Ground reaction	Bearing		
				(kN)	(kN・m)	(kN)	(kN・m)	Required ratio		Desing	e （m）		(Allowable)	Q1 (kN/m2)	Q2 (kN/m2)	(kN/m2)		
Abo Gabal Regulator	1	Long.	Regular	14,280.64	118,050.05	222.51	1,726.95	1.50	≦	38.51	0.29	≦	2.70	75.09	60.53		OK	
	2	Long.	Regular	16,190.06	131,176.82	1,861.31	3,835.16	1.50	≦	5.22	0.24	≦	2.70	83.71	70.04		OK	
	3	Long.	Regular	20,949.17	171,879.71	245.56	1,692.48	1.50	≦	51.19	0.19	≦	2.70	106.47	92.47		OK	
	4	Lateral.	Regular	14,531.51	94,454.82	403.70	2,652.31	1.50	≦	21.60	0.18	≦	2.17	74.73	63.27		OK	
	5	Lateral.	Regular	16,190.06	105,235.40	714.26	4,449.84	1.50	≦	13.60	0.27	≦	2.17	86.46	67.30		OK	
	6	Lateral.	Regular	20,949.17	136,169.61	914.61	4,015.14	1.50	≦	13.74	0.19	≦	2.17	108.20	90.75		OK	
	7	Long.	Seism	16,154.06	130,782.62	3,541.61	7,509.83	1.15	≦	2.74	0.46	≦	5.40	89.77	63.64		OK	
	8	Long.	Seism	20,913.17	171,588.11	1,673.05	4,606.68	1.15	≦	7.50	0.33	≦	5.40	111.44	87.17		OK	
	9	Lateral.	Seism	14,495.51	94,220.82	2,273.50	6,474.08	1.15	≦	3.83	0.45	≦	4.33	83.12	54.53		OK	
	10	Lateral.	Seism	16,154.06	105,001.40	1,815.29	5,032.07	1.15	≦	5.34	0.31	≦	4.33	87.68	65.73		OK	
	11	Lateral.	Seism	20,913.17	135,935.61	1,673.05	4,606.68	1.15	≦	7.50	0.22	≦	4.33	109.39	89.22		OK	
	12	Long.	Seism	14,635.51	120,995.69	1,717.28	4,796.56	1.15	≦	5.11	0.50	≦	5.40	82.36	56.63		OK	
	13	Long.	Regular	14,043.24	121,596.92	967.19	2,203.10	1.50	≦	8.71	0.72	≦	2.70	84.46	48.90		OK	

Note 1) Ground reaction for the bearing capacity should be consideration in Chapter 12

Table11-2.7 Summary of the stability analysis (Sahelyia regulator)

Summary table of result on the stability examination for Sahelyia Regulator

Pier	Case	Direction	Condition	Vertical force	Resistant moment	Horizontal force	Torque moment	For the sliding			For the fall down			note1)For the ground reaction			Judge	Remarks
				V	V・x	H	H・y	Safe ratio			Eccentricity		B/6	Ground reaction	Ground reaction	Bearing		
				(kN)	(kN・m)	(kN)	(kN・m)	Required ratio		Desing	e （m）		(Allowable)	Q1 (kN/m2)	Q2 (kN/m2)	(kN/m2)		
Sahelyia Regulator	1	Long.	Regular	9,296.64	72,509.84	129.69	1,193.07	1.50	≦	43.01	0.33	≦	2.53	98.76	75.99		OK	
	2	Long.	Regular	10,778.76	82,364.34	1,517.09	3,776.88	1.50	≦	4.26	0.39	≦	2.53	116.90	85.71		OK	
	3	Long.	Regular	13,479.82	103,926.34	149.64	1,190.92	1.50	≦	54.05	0.20	≦	2.53	136.69	116.69		OK	
	4	Lateral.	Regular	9,411.63	32,940.71	243.00	1,941.57	1.50	≦	23.24	0.21	≦	1.17	104.38	72.53		OK	
	5	Lateral.	Regular	10,778.76	37,725.67	615.62	4,543.28	1.50	≦	10.51	0.42	≦	1.17	137.77	64.83		OK	
	6	Lateral.	Regular	13,479.82	47,179.37	362.13	1,897.56	1.50	≦	22.33	0.14	≦	1.17	141.89	111.49		OK	
	7	Long.	Seism	10,763.76	82,207.59	2,639.74	6,633.25	1.15	≦	2.45	0.65	≦	5.07	127.12	75.21		OK	
	8	Long.	Seism	13,464.82	103,812.34	1,077.19	3,360.93	1.15	≦	7.50	0.36	≦	5.07	144.53	108.57		OK	
	9	Lateral.	Seism	9,396.63	32,888.21	1,529.00	4,980.70	1.15	≦	3.69	0.53	≦	2.33	128.43	48.19		OK	
	10	Lateral.	Seism	10,763.76	37,673.17	1,204.34	3,804.37	1.15	≦	5.36	0.35	≦	2.33	131.51	70.81		OK	
	11	Lateral.	Seism	13,464.82	47,126.87	1,077.19	3,360.93	1.15	≦	7.50	0.25	≦	2.33	153.67	99.43		OK	
	12	Long.	Seism	9,498.63	74,072.27	1,127.58	3,572.45	1.15	≦	5.05	0.57	≦	5.07	109.36	69.19		OK	
	13	Long.	Regular	8,513.80	73,537.34	389.29	1,397.34	1.50	≦	13.12	1.20	≦	2.53	117.92	42.11		OK	

Note 1) Ground reaction for the bearing capacity should be consideration in Chapter 12

11-3 Examination of regulators' structure

The structure of the regulators is examined using a 3D frame analysis. The necessary conditions and examination cases are shown as follows.

(1) Necessary safety ratio and allowable stress

a) Concrete

Standard concrete cube (150mm x 150mm x 150mm) is used to test compressive strength. Concrete grade for plain concrete should be no lower than 15N/mm^2 at 28 days. The Egyptian code requirements for reinforced concrete and plain concrete are:

For plain concrete Fc_{cube}= 20 N/mm^2 ($Fc_{cyl.}$= 17 N/mm^2)
For reinforced concrete Fc_{cube}= 25 N/mm^2 ($Fc_{cyl.}$= 21 N/mm^2) clause (2.3.2.1)

Note: 'cube': cube type, and 'cyl': cylinder type

Table11-3.1 Allowable concrete stress (Egyptian code)

Items		Concrete strength at 28 days			Remarks
Reinforced concrete	1) 28 days strength: σck (N/mm2)	**20(cube) 17(cyl.)**	**25(cube) 21(cyl.)**	**30(cube) 25(cyl.)**	**Egyptian code Table (5-1) page 5-2** All stresses of the fc cube
	2) Allowable compressive stress due to bending: σca (N/mm2)	**8**	**9.5**	**10.5**	
Plain concrete	1) 28 days strength: σck (N/mm2)	**15(cube) 12.5(cyl.)**	**20(cube) 17(cyl.)**	Minimum 15 (page 2-4)	
	2) Allowable compressive stress: σca (N/mm2)	**4.5**	**6**	=0.3 fcu(σck)	

b) Shearing stress of concrete

Table11-3.2 Shearing stress of concrete (Egyptian code)

Items		Concrete strength at 28 days				Remarks
28 days strength: σck (N/mm^2)		**20(cube) 17(cyl.)**	**25(cube) 21(cyl.)**	**30(cube) 25(cyl.)**		**Egyptian code Table (5-1)**
Sharing stress	1) burden by concrete only (slabs, foundation) qc (N/mm^2)	0.8	0.9	0.9		
	- burden by concrete only (the others) qc (N/mm^2)	0.6	0.7	0.7		
	2) burden by concrete and diagonal tension bar: q2 (N/mm^2)	1.7	1.9	2.1		

Note: In case tension bar is needed, "$qs=q_{actual} - 0.5$ qc" should be evaluated

c) Applied situation and concrete structure

Table11-3.3 Application to section of cast-in-place concrete

Strength of 28 days design and concrete type	**Applied situation and structure**	**Egyptian code**
Plain concrete σck=20 N/mm^2 (cube) 【σck=17 N/mm^2(cyl.)】	・Bed concrete of structure foundation (leveling concrete) ・Plain concrete structure, foundation concrete etc. ・Situation of no moment is usually induced.	
Reinforced concrete σck=25 N/mm^2 (cube) 【σck=21 N/mm^2(cyl.)】	・Main body of regulator, canal structure, flume, conduit, siphon etc. ・Structure which is affected by bending moment	
Reinforced concrete σck=30 N/mm^2 (cube) 【σck=25 N/mm^2(cyl.)】	・Very important structures or elements	

d) Sheet pile

Allowable design stresses of sheet piling are set depending on applied and/or available sheet pile. Standard allowable stresses in Egypt are shown in table below:

Table11-3.4 Allowable stress of sheet pile

Category		Allowable stress (N/mm2)			
		bending tension	bending compression	sharing	Japanese standard
Light sheet pile	SS 400	140	140	80	
Sheet pile	SY 295	180	180	100	
Category		**Allowable stress (N/mm2)**			**Egyptian code Table (5-1) concrete 2-6-3-1 steel code**
		bending tension =0.58f_y	**bending compression**=0.58f_y	**sharing** = 0.35 f_y	
St(yield/ultimatum)	240/350	140	140	84	
	280/450	160	160	98	
	360/520	200	200	126	

Note: Highlighted grade shows the standard grade used for regulator design

e) Reinforced steel bar

Table11-3.5 Allowable stress intensity for reinforcing bar

Items	Category of available steel bar (N/mm2)				Remarks
1) Strength of ultimatum	Steel 240/350		Steel 360/520		Egyptian code
2) Condition	Normal	Seismic	Normal	Seismic	
a) General situation	140	161	200	230	

Note: Egyptian allowable tensile stress of reinforcing bar is generally 200 N/mm^2. Allowable tensile stress of reinforcing bar in seismic case is 1.15 times that; namely, 200×1.15= 230N/mm^2.

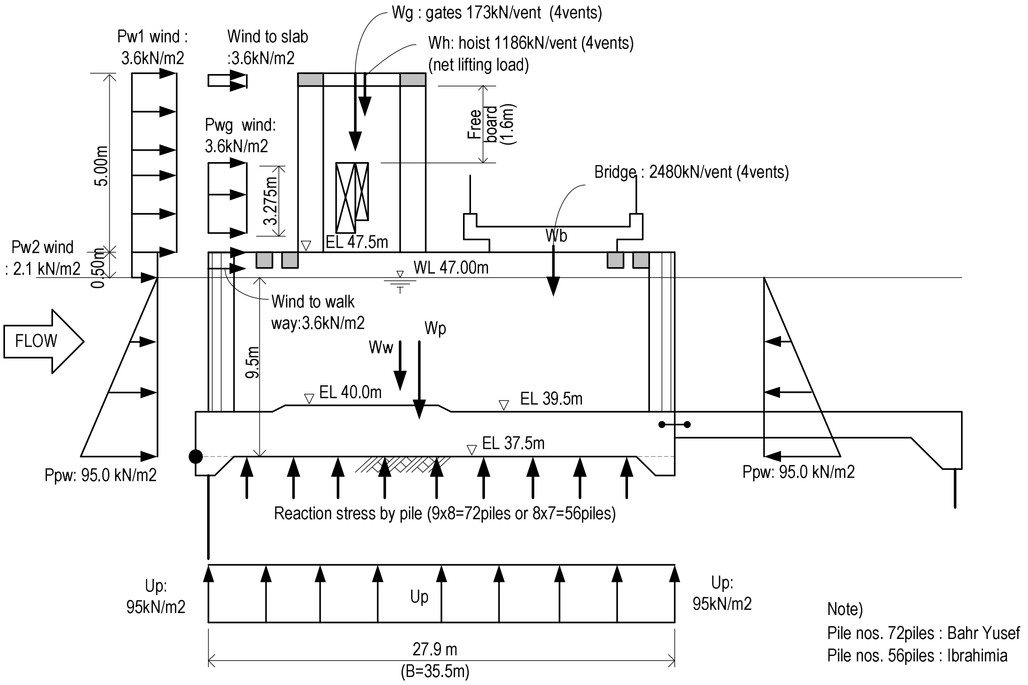
Note: Available reinforced steel bars are: D10, D12, D14, D16, D18, D20, D22, D25, D28, D32, and D50

(2) Examination cases

The cases should be examined under the same conditions as those in the stability analysis shown in chapter 11-1 and 11-2. The load conditions for examination should generally be the same as well, but the exact weights and force are shown in Figures 11-3.1 to 11-3.29. Since the Bahr Yusef and Ibrahimia regulators applied pile foundation, (see “Chapter 12: Foundation Works to Regulator"), the stress induced by the piles onto the foundation slab should be examined.

The Diroutiah regulator rather than the Badraman regulator should be examined, because it has a larger number of vents than the Badraman regulator even though it has a similar structure.

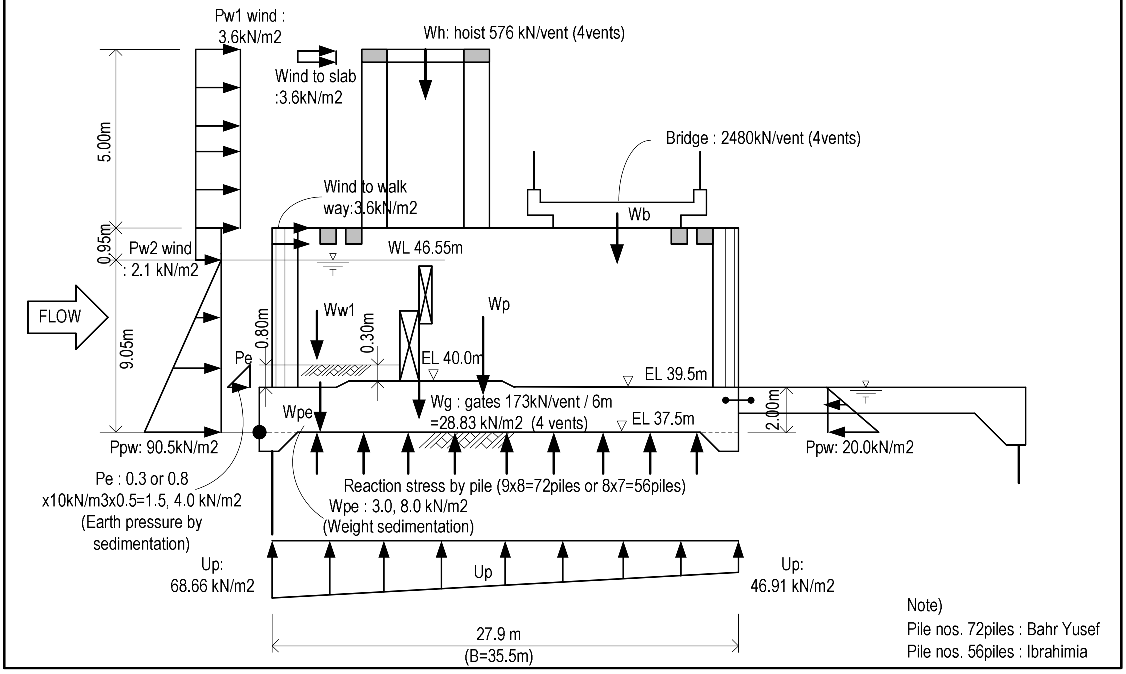
【CASE 1 : Regular / Longitudinal direction/ H.H.W.L. / Full OP】



Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

【CASE 2 : Regular / Longitudinal direction/ H.WL+0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

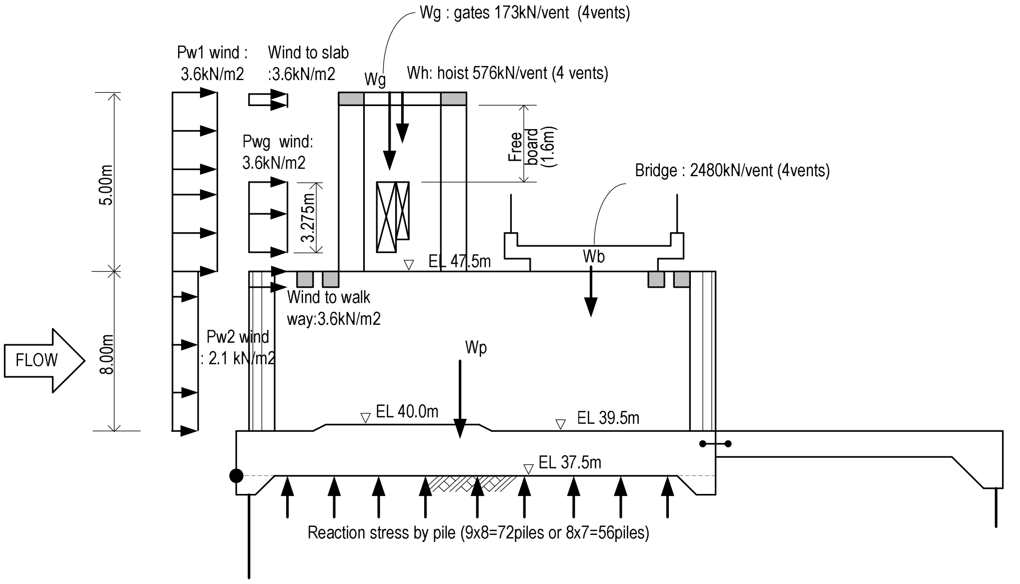

Pw1 wind : 3.6kN/m2
Wh: hoist 576 kN/vent (4vents)
Wind to slab :3.6kN/m2
5.00m
Bridge : 2480kN/vent (4vents)
Wind to walk way:3.6kN/m2
Wb
0.95m
Pw2 wind : 2.1 kN/m2
WL 46.55m
FLOW
Ww1
Wp
0.80m
0.30m
9.05m
Pe
EL 40.0m
EL 39.5m
Wpe
Wg : gates 173kN/vent / 6m =28.83 kN/m2 (4 vents)
EL 37.5m
2.00m
Ppw: 90.5kN/m2
Ppw: 20.0kN/m2
Pe : 0.3 or 0.8 x10kN/m3x0.5=1.5, 4.0 kN/m2 (Earth pressure by sedimentation)
Reaction stress by pile (9x8=72piles or 8x7=56piles)
Wpe : 3.0, 8.0 kN/m2 (Weight sedimentation)
Up: 68.66 kN/m2
Up
Up: 46.91 kN/m2
27.9 m
(B=35.5m)

Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

Figure11-3.1 Load condition for Bahr Yusef and Ibrahimia regulators (case 1, 2)

Bahr Yusef and Ibrahimia

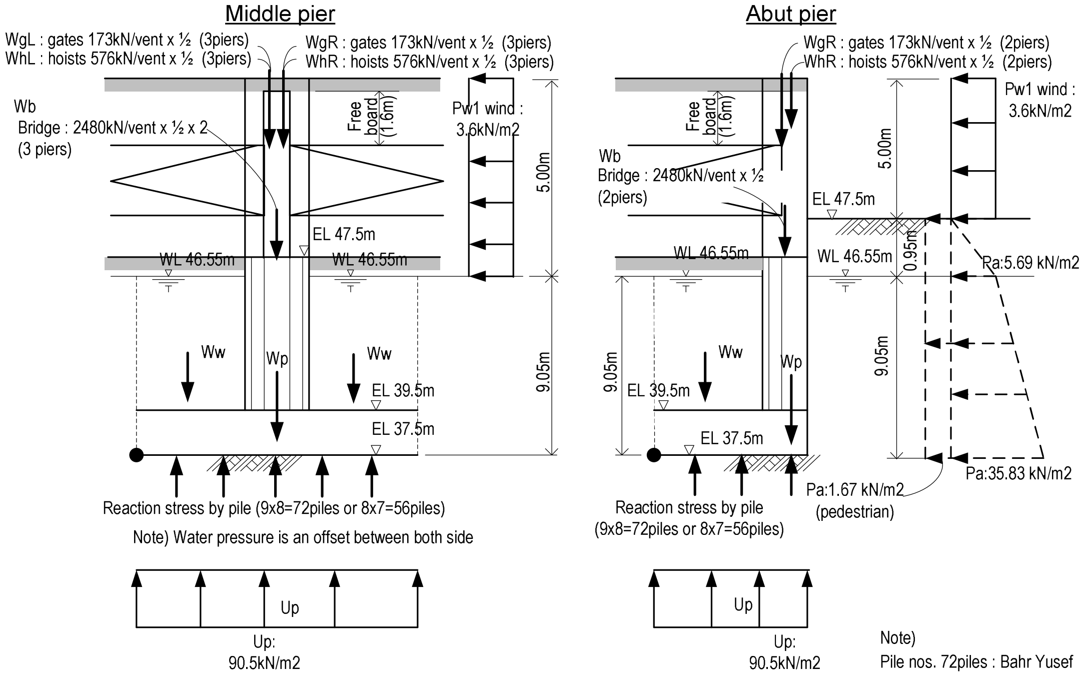
【CASE 3 : Regular / Longitudinal direction/ No. water / Full OP】


Wg : gates 173kN/vent (4vents)
Pw1 wind : 3.6kN/m2
Wind to slab :3.6kN/m2
Wg
Wh: hoist 576kN/vent (4 vents)
Free board (1.6m)
Bridge : 2480kN/vent (4vents)
Pwg wind: 3.6kN/m2
5.00m
3.275m
EL 47.5m
Wb
Wind to walk way:3.6kN/m2
FLOW
8.00m
Pw2 wind : 2.1 kN/m2
Wp
EL 40.0m
EL 39.5m
EL 37.5m
Reaction stress by pile (9x8=72piles or 8x7=56piles)

Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

【CASE 4 : Regular / Lateral direction / H.W.L. +0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

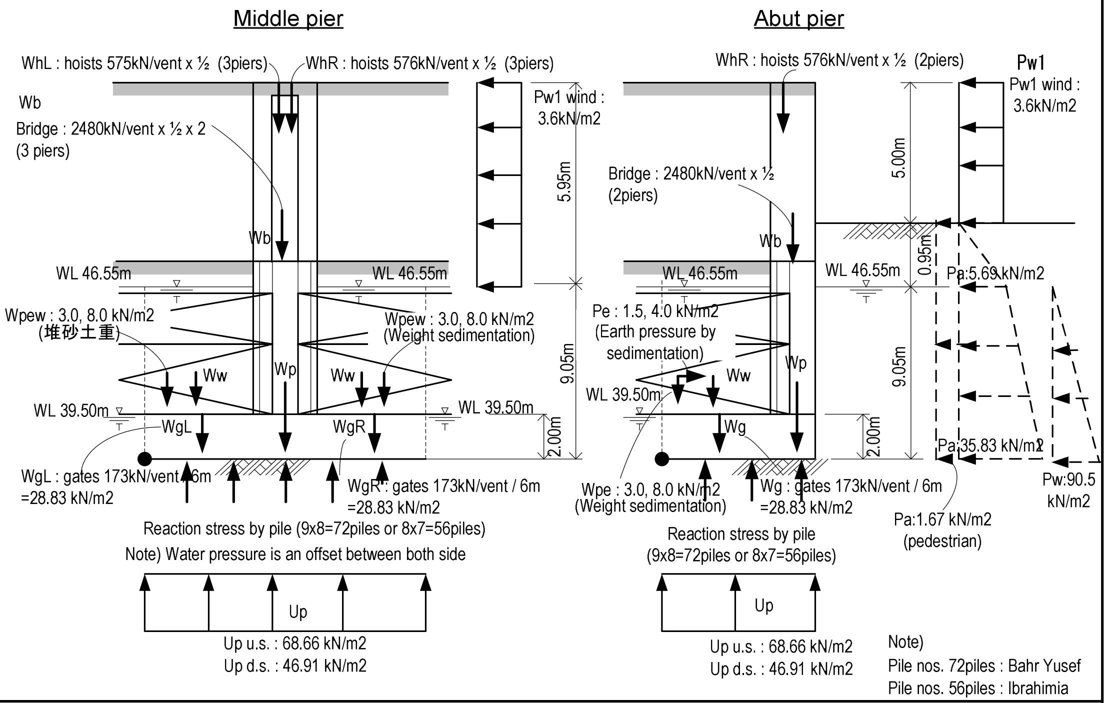

Middle pier
WgL : gates 173kN/vent x ½ (3piers)
WhL : hoists 576kN/vent x ½ (3piers)
WgR : gates 173kN/vent x ½ (3piers)
WhR : hoists 576kN/vent x ½ (3piers)
Wb
Bridge : 2480kN/vent x ½ x 2
(3 piers)
Free board (1.6m)
Pw1 wind : 3.6kN/m2
5.00m
EL 47.5m
WL 46.55m
WL 46.55m
Ww
Wp
Ww
EL 39.5m
9.05m
EL 37.5m
Reaction stress by pile (9x8=72piles or 8x7=56piles)
Note) Water pressure is an offset between both side
Up
Up: 90.5kN/m2
Abut pier
WgR : gates 173kN/vent x ½ (2piers)
WhR : hoists 576kN/vent x ½ (2piers)
Pw1 wind : 3.6kN/m2
Free board (1.6m)
Wb
Bridge : 2480kN/vent x ½
(2piers)
5.00m
EL 47.5m
WL 46.55m
WL 46.55m
0.95m
Pa:5.69 kN/m2
9.05m
Ww
Wp
EL 39.5m
9.05m
EL 37.5m
Pa:35.83 kN/m2
Pa:1.67 kN/m2 (pedestrian)
Reaction stress by pile (9x8=72piles or 8x7=56piles)
Up
Up: 90.5kN/m2

Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

Figure11-3.2 Load condition for Bahr Yusef and Ibrahimia regulators (case 3, 4)

【CASE 5 : Regular / Lateral direction/ H.W.L.+0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC



【CASE 6 : Regular / Lateral direction / No water / Full OP】

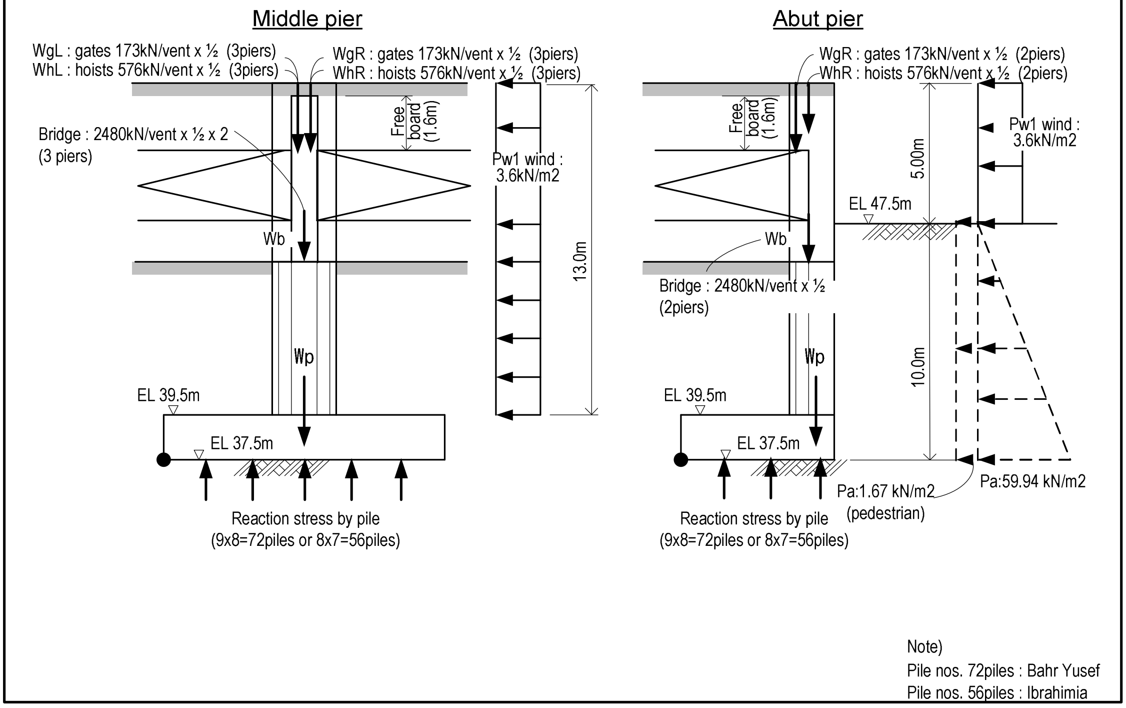
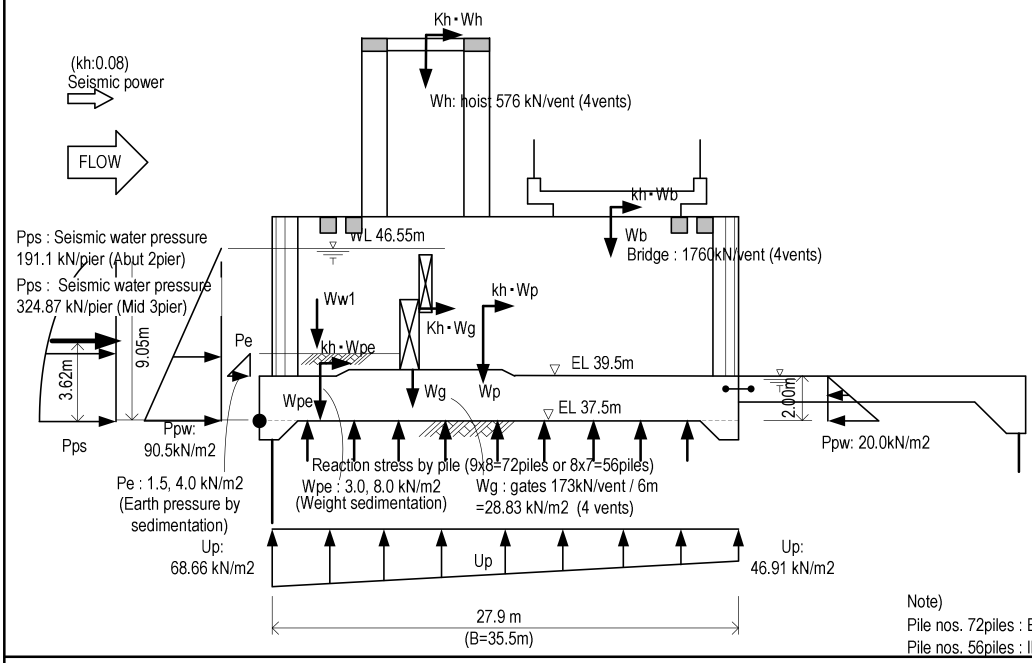

Middle pier
Abut pier
WgL : gates 173kN/vent x ½ (3piers)
WhL : hoists 576kN/vent x ½ (3piers)
WgR : gates 173kN/vent x ½ (3piers)
WhR : hoists 576kN/vent x ½ (3piers)
Free board (1.6m)
Bridge : 2480kN/vent x ½ x 2
(3 piers)
Pw1 wind :
3.6kN/m2
Wb
13.0m
Wp
EL 39.5m
EL 37.5m
Reaction stress by pile
(9x8=72piles or 8x7=56piles)
WgR : gates 173kN/vent x ½ (2piers)
WhR : hoists 576kN/vent x ½ (2piers)
Free board (1.6m)
Pw1 wind :
3.6kN/m2
5.00m
EL 47.5m
Wb
Bridge : 2480kN/vent x ½
(2piers)
Wp
10.0m
EL 39.5m
EL 37.5m
Pa:1.67 kN/m2
(pedestrian)
Pa:59.94 kN/m2
Reaction stress by pile
(9x8=72piles or 8x7=56piles)
Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

Figure11-3.3 Load condition for Bahr Yusef and Ibrahimia regulators (case 5, 6)

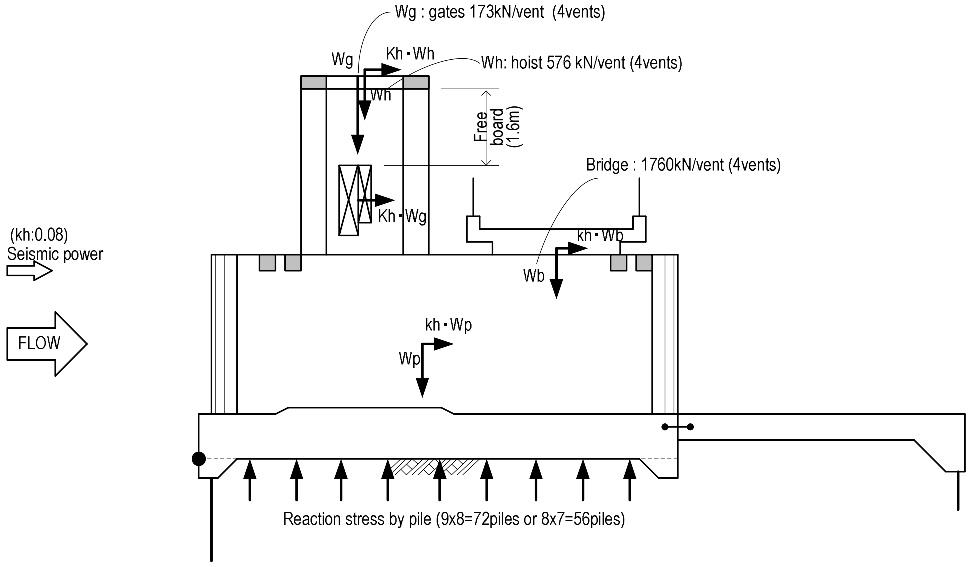
【CASE 7： Seism / Longitudinal direction / H.W.L. +0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC



Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

【CASE 8：Seism / Longitudinal direction / No water / Full OP】

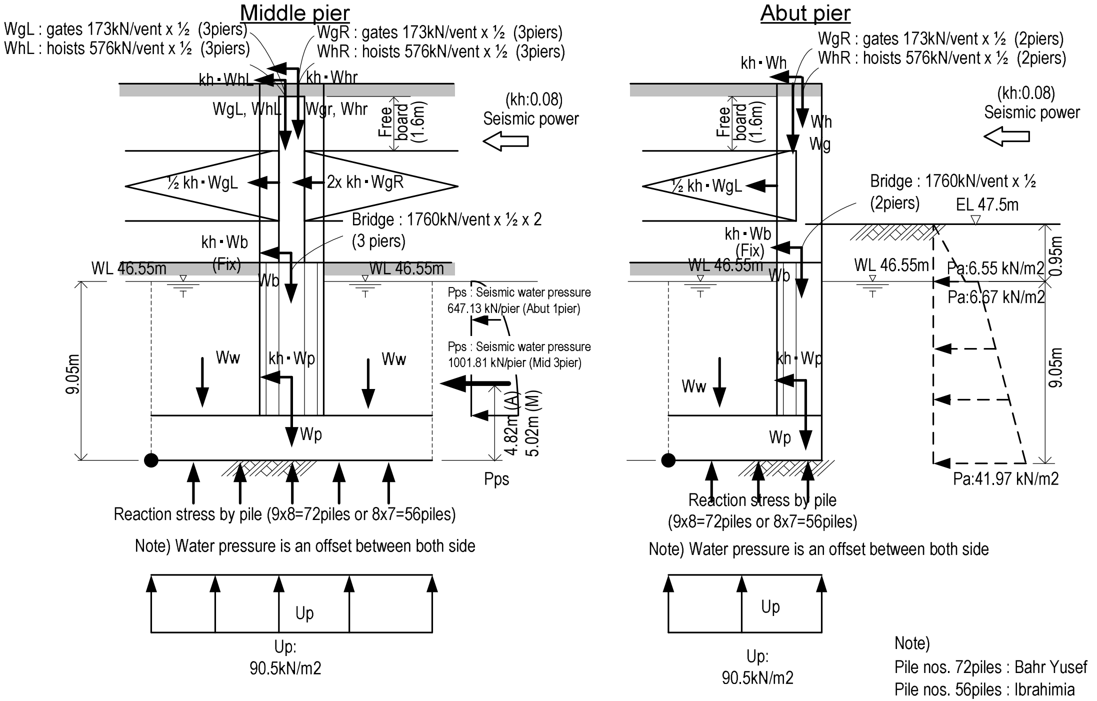

Wg : gates 173kN/vent (4vents)
Wg
Kh・Wh
Wh: hoist 576 kN/vent (4vents)
Wh
Free board (1.6m)
Bridge : 1760kN/vent (4vents)
Kh・Wg
(kh:0.08)
Seismic power
kh・Wb
Wb
FLOW
kh・Wp
Wp
Reaction stress by pile (9x8=72piles or 8x7=56piles)

Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

Figure11-3.4 Load condition for Bahr Yusef and Ibrahimia regulators (case 7, 8)

【CASE 9 : Seism / Lateral direction / H.W.L + 0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC


Middle pier
WgL : gates 173kN/vent x ½ (3piers)
WhL : hoists 576kN/vent x ½ (3piers)
WgR : gates 173kN/vent x ½ (3piers)
WhR : hoists 576kN/vent x ½ (3piers)
kh・WhL
kh・Whr
WgL, WhL
Wgr, Whr
Free board (1.6m)
(kh:0.08)
Seismic power
½ kh・WgL
2x kh・WgR
Bridge : 1760kN/vent x ½ x 2
(3 piers)
kh・Wb
(Fix)
WL 46.55m
Wb
WL 46.55m
Pps : Seismic water pressure
647.13 kN/pier (Abut 1pier)
Pps : Seismic water pressure
1001.81 kN/pier (Mid 3pier)
9.05m
Ww
kh・Wp
Ww
4.82m (A)
5.02m (M)
Wp
Pps
Reaction stress by pile (9x8=72piles or 8x7=56piles)
Note) Water pressure is an offset between both side
Up
Up:
90.5kN/m2
Abut pier
WgR : gates 173kN/vent x ½ (2piers)
WhR : hoists 576kN/vent x ½ (2piers)
kh・Wh
Free board (1.6m)
Wh
Wg
(kh:0.08)
Seismic power
½ kh・WgL
Bridge : 1760kN/vent x ½
(2piers)
EL 47.5m
kh・Wb
(Fix)
WL 46.55m
Wb
WL 46.55m
Pa:6.55 kN/m2
0.95m
Pa:6.67 kN/m2
Ww
kh・Wp
9.05m
Wp
Pa:41.97 kN/m2
Reaction stress by pile
(9x8=72piles or 8x7=56piles)
Note) Water pressure is an offset between both side
Up
Up:
90.5kN/m2
Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

【CASE 10 : Seism / Lateral direction / H.W.L + 0.25m level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

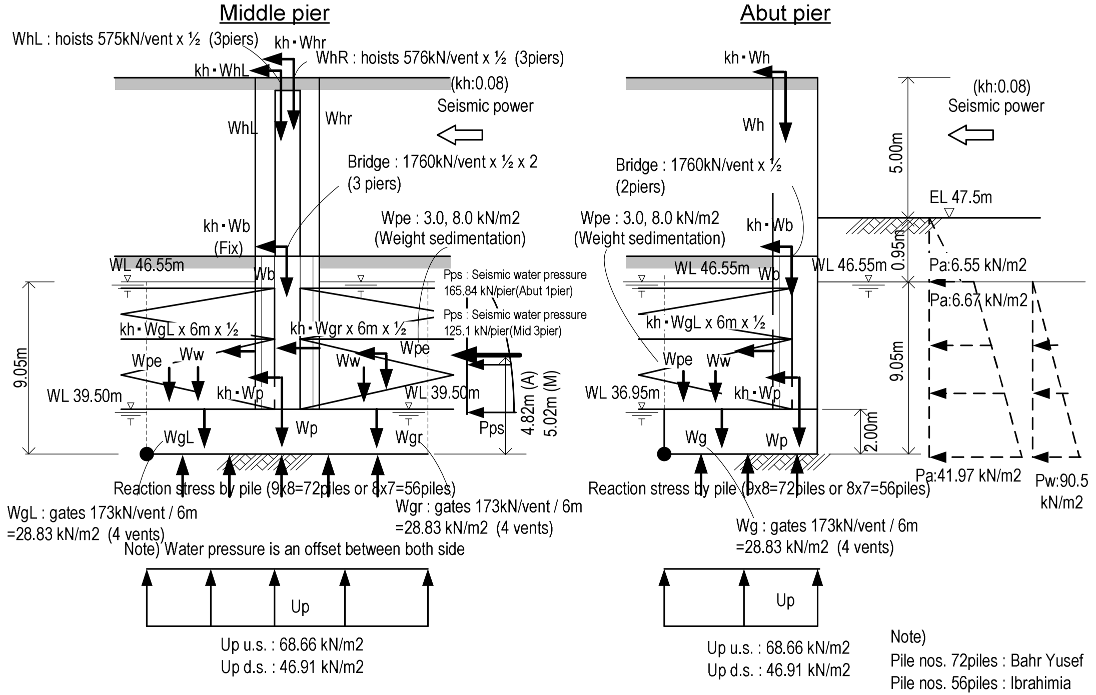
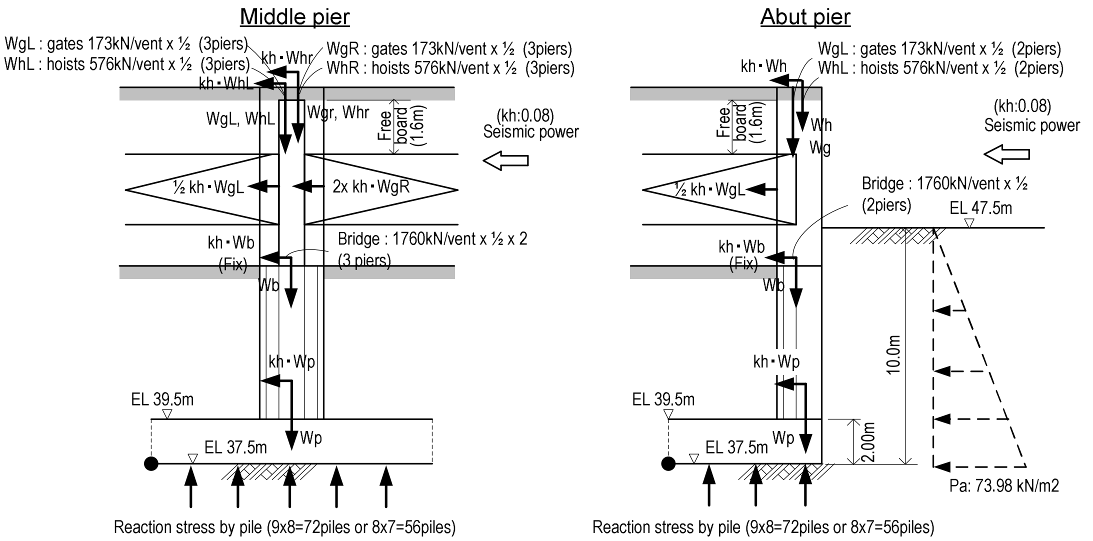


Figure11-3.5 Load condition for Bahr Yusef and Ibrahimia regulators (case 9, 10)

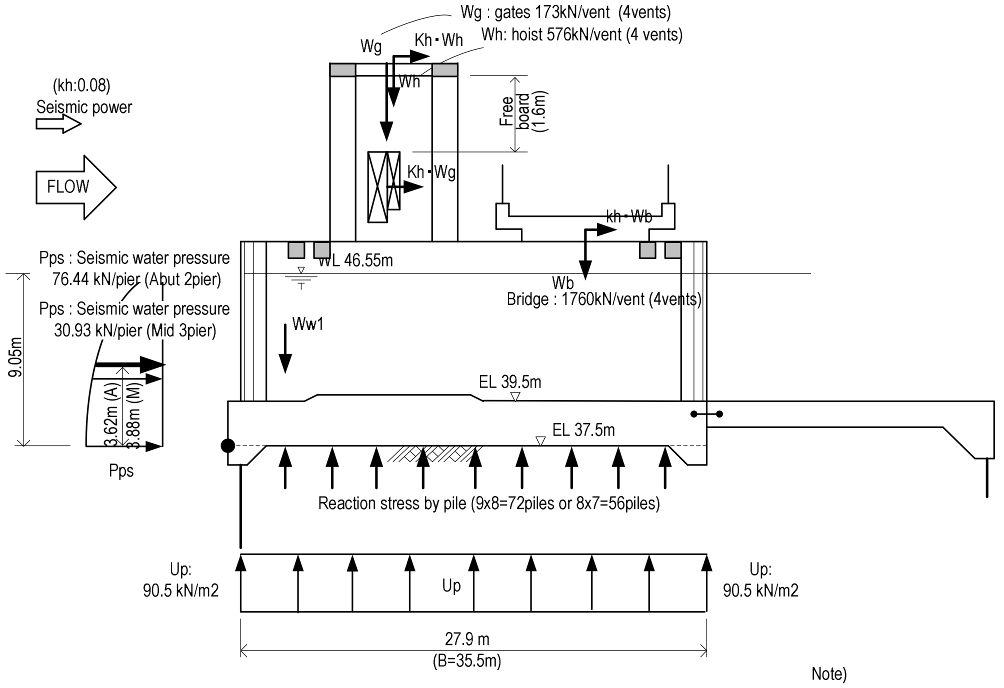
【CASE 11 : Seism / Lateral direction / No water / Full OP】


Middle pier
WgL : gates 173kN/vent x ½ (3piers)
WhL : hoists 576kN/vent x ½ (3piers)
kh・Whr
WgR : gates 173kN/vent x ½ (3piers)
WhR : hoists 576kN/vent x ½ (3piers)
kh・WhL
WgL, WhL
Wgr, Whr
Free board (1.6m)
(kh:0.08)
Seismic power
½ kh・WgL
2x kh・WgR
kh・Wb
(Fix)
Bridge : 1760kN/vent x ½ x 2
(3 piers)
Wb
kh・Wp
EL 39.5m
EL 37.5m
Wp
Reaction stress by pile (9x8=72piles or 8x7=56piles)
Abut pier
kh・Wh
WgL : gates 173kN/vent x ½ (2piers)
WhL : hoists 576kN/vent x ½ (2piers)
Free board (1.6m)
Wh
Wg
(kh:0.08)
Seismic power
½ kh・WgL
Bridge : 1760kN/vent x ½
(2piers)
EL 47.5m
kh・Wb
(Fix)
Wb
10.0m
kh・Wp
EL 39.5m
EL 37.5m
Wp
2.00m
Pa: 73.98 kN/m2
Reaction stress by pile (9x8=72piles or 8x7=56piles)

Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

【CASE 12 : Seism / Longitudinal direction/ H.W.L.+0.25m water level / Full OP】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC


Wg : gates 173kN/vent (4vents)
Wh: hoist 576kN/vent (4 vents)
Wg
Kh・Wh
Wh
(kh:0.08)
Seismic power
Free board (1.6m)
FLOW
Kh・Wg
kh・Wb
Pps : Seismic water pressure
76.44 kN/pier (Abut 2pier)
Pps : Seismic water pressure
30.93 kN/pier (Mid 3pier)
WL 46.55m
Wb
Bridge : 1760kN/vent (4vents)
Ww1
9.05m
3.62m (A)
3.88m (M)
Pps
EL 39.5m
EL 37.5m
Reaction stress by pile (9x8=72piles or 8x7=56piles)
Up:
90.5 kN/m2
Up
Up:
90.5 kN/m2
27.9 m
(B=35.5m)

Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

Figure11-3.6 Load condition for Bahr Yusef and Ibrahimia regulators (case 11, 12)

【CASE 13 : / Regular / Longitudinal direction/ H.W.L.+0.25m water level / Maintenance case】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC
: One vent closed with stoplog gates and the others fully opened

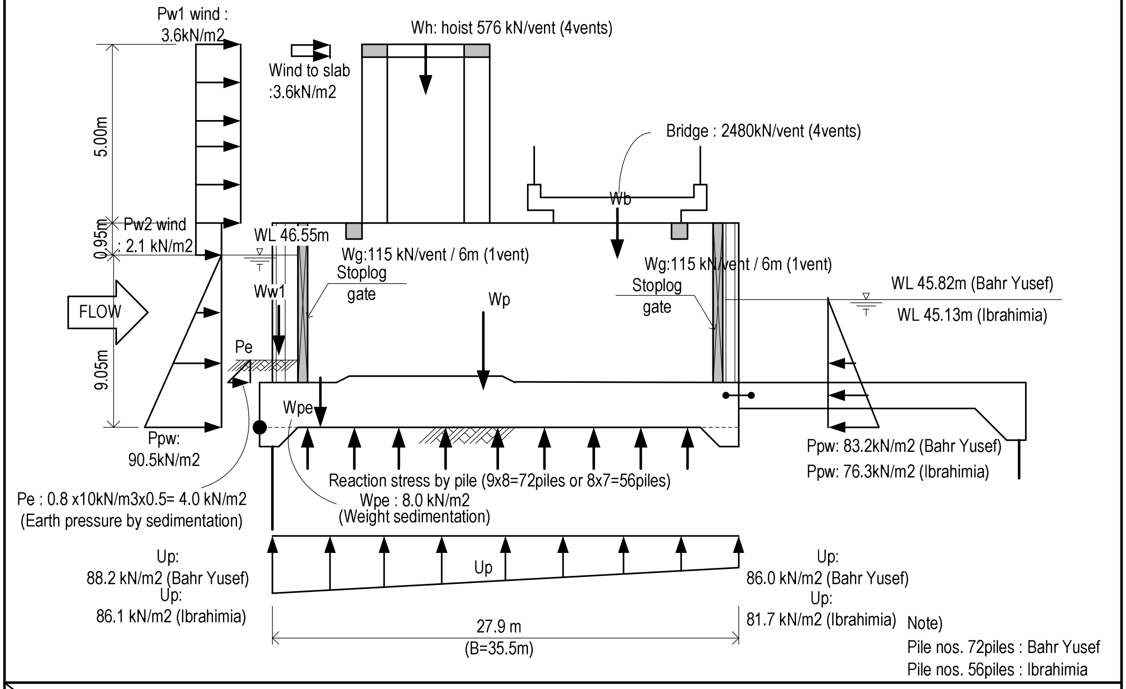
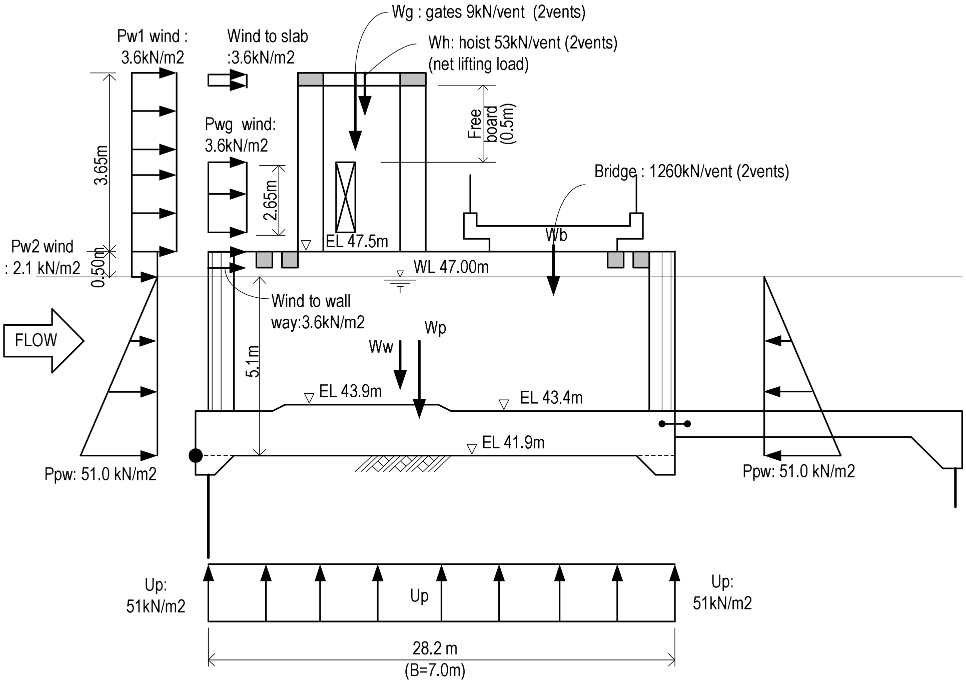

Pw1 wind : 3.6kN/m2
Wh: hoist 576 kN/vent (4vents)
Wind to slab :3.6kN/m2
Bridge : 2480kN/vent (4vents)
5.00m
Wb
Pw2 wind : 2.1 kN/m2
0.95m
WL 46.55m
Wg:115 kN/vent / 6m (1vent)
Stoplog gate
Wg:115 kN/vent / 6m (1vent)
Stoplog gate
WL 45.82m (Bahr Yusef)
WL 45.13m (Ibrahimia)
FLOW
Ww1
Wp
Pe
9.05m
Wpe
Ppw: 90.5kN/m2
Ppw: 83.2kN/m2 (Bahr Yusef)
Ppw: 76.3kN/m2 (Ibrahimia)
Reaction stress by pile (9x8=72piles or 8x7=56piles)
Pe : 0.8 x10kN/m3x0.5= 4.0 kN/m2
(Earth pressure by sedimentation)
Wpe : 8.0 kN/m2
(Weight sedimentation)
Up: 88.2 kN/m2 (Bahr Yusef)
Up: 86.1 kN/m2 (Ibrahimia)
Up
Up: 86.0 kN/m2 (Bahr Yusef)
Up: 81.7 kN/m2 (Ibrahimia)
27.9 m
(B=35.5m)
Note)
Pile nos. 72piles : Bahr Yusef
Pile nos. 56piles : Ibrahimia

Figure11-3.7 Load condition for Bahr Yusef and Ibrahimia regulators (case 13)

Badraman

【CASE 1： Regular / Longitudinal direction/ H.H.W.L. / Full OP】



【CASE 2：Regular / Longitudinal direction/ H.WL+0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

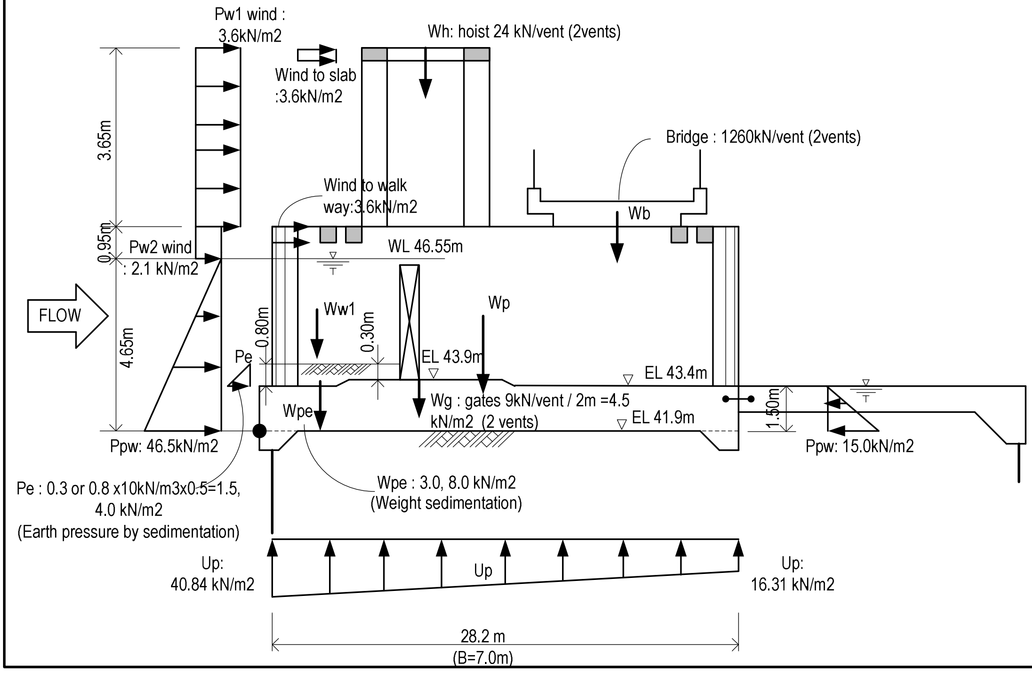
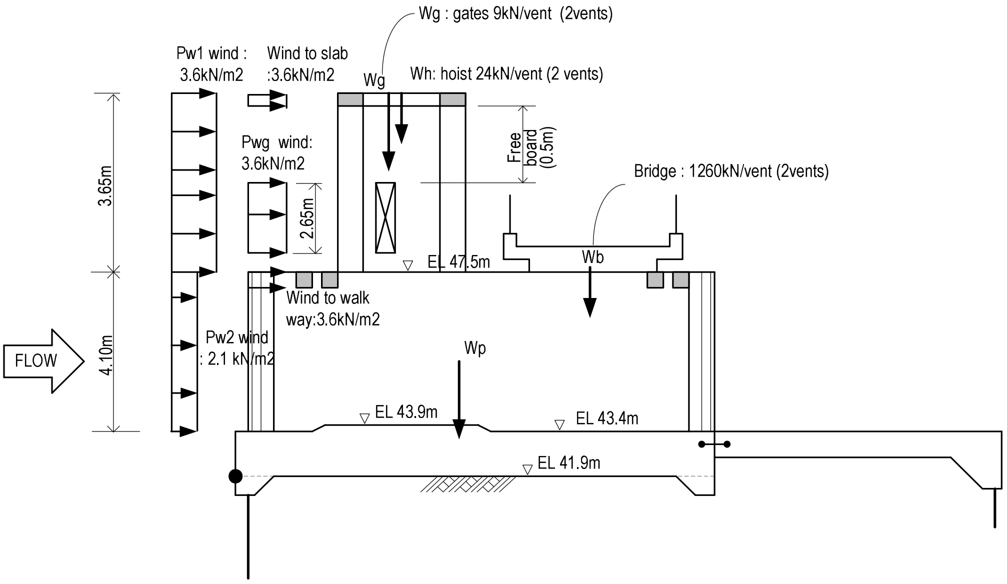

Pw1 wind : 3.6kN/m2
Wh: hoist 24 kN/vent (2vents)
Wind to slab :3.6kN/m2
3.65m
Bridge : 1260kN/vent (2vents)
Wind to walk way:3.6kN/m2
Wb
0.95m
Pw2 wind : 2.1 kN/m2
WL 46.55m
FLOW
Ww1
Wp
0.80m
0.30m
4.65m
Pe
EL 43.9m
EL 43.4m
Wpe
Wg : gates 9kN/vent / 2m =4.5 kN/m2 (2 vents)
EL 41.9m
1.50m
Ppw: 46.5kN/m2
Ppw: 15.0kN/m2
Pe : 0.3 or 0.8 x10kN/m3x0.5=1.5, 4.0 kN/m2 (Earth pressure by sedimentation)
Wpe : 3.0, 8.0 kN/m2 (Weight sedimentation)
Up: 40.84 kN/m2
Up
Up: 16.31 kN/m2
28.2 m
(B=7.0m)

Figure 11-3.8 Load condition for Badraman regulator (case 1, 2)

【CASE 3：Regular / Longitudinal direction/ No. water / Full OP】



【CASE 4：Regular / Lateral direction / H.W.L. +0.25m water level / Full OP】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

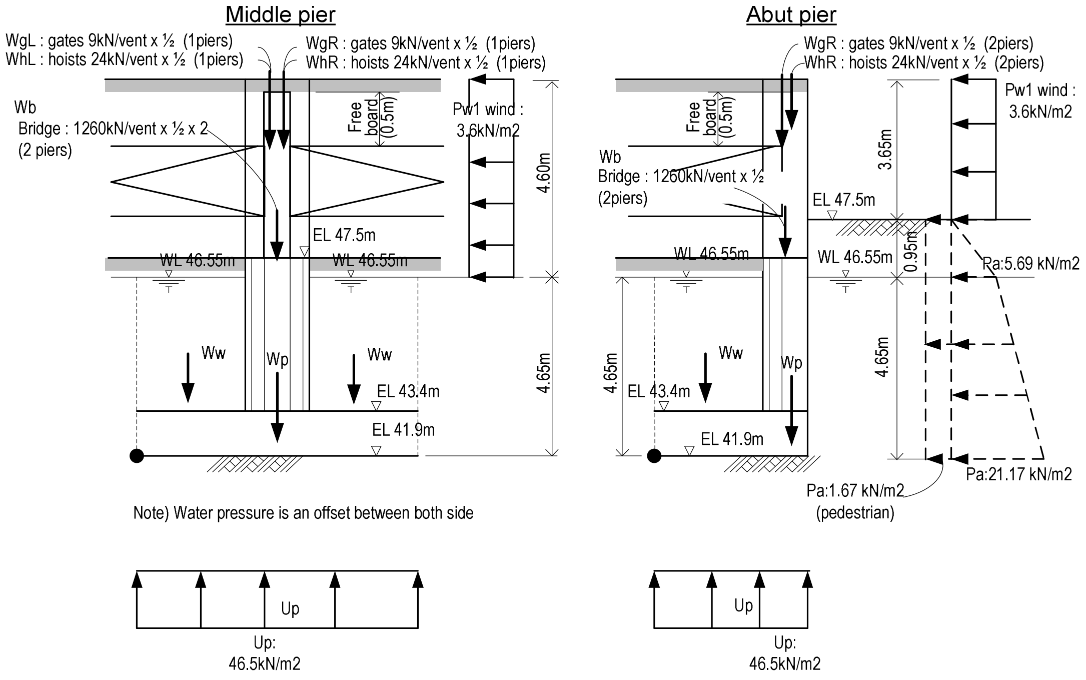
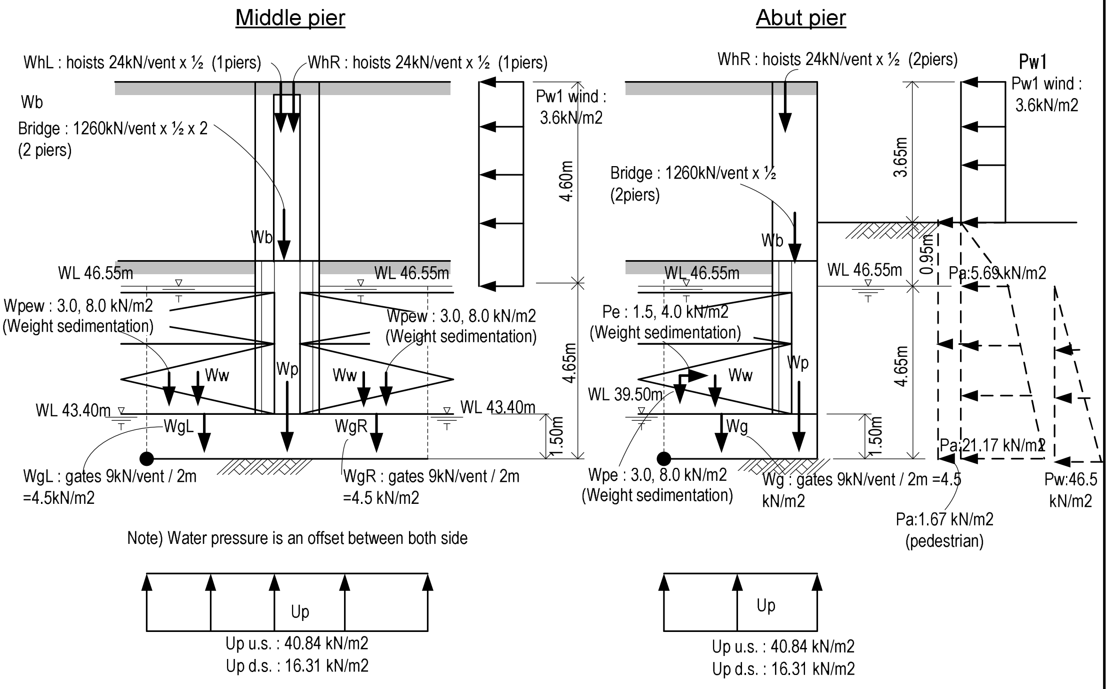


Figure 11-3.9 Load condition for Badraman regulator (case 3, 4)

【CASE 5 : Regular / Lateral direction/ H.W.L.+0.25m water level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC



【CASE 6 : Regular / Lateral direction / No water / Full OP】

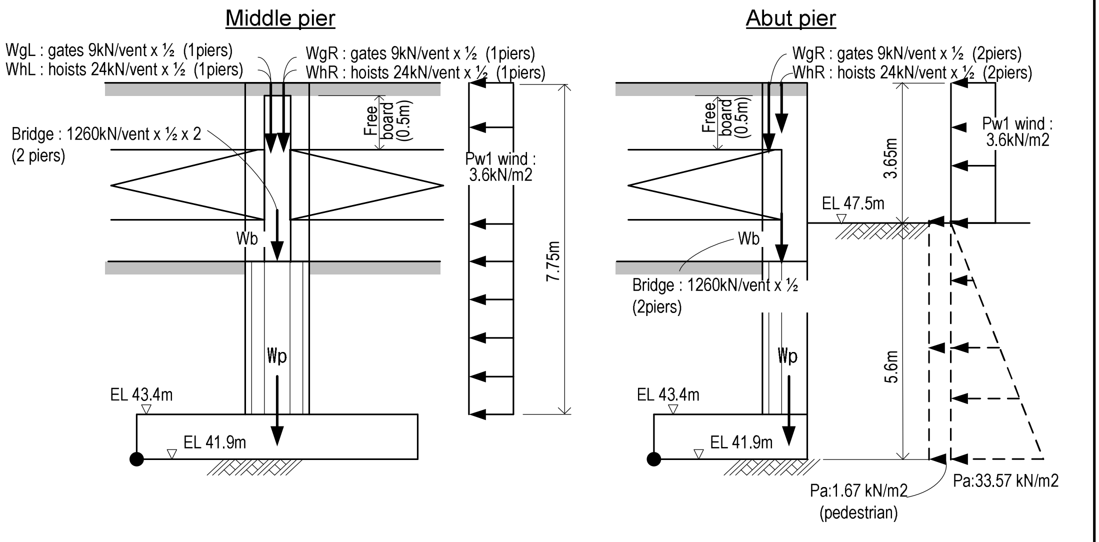
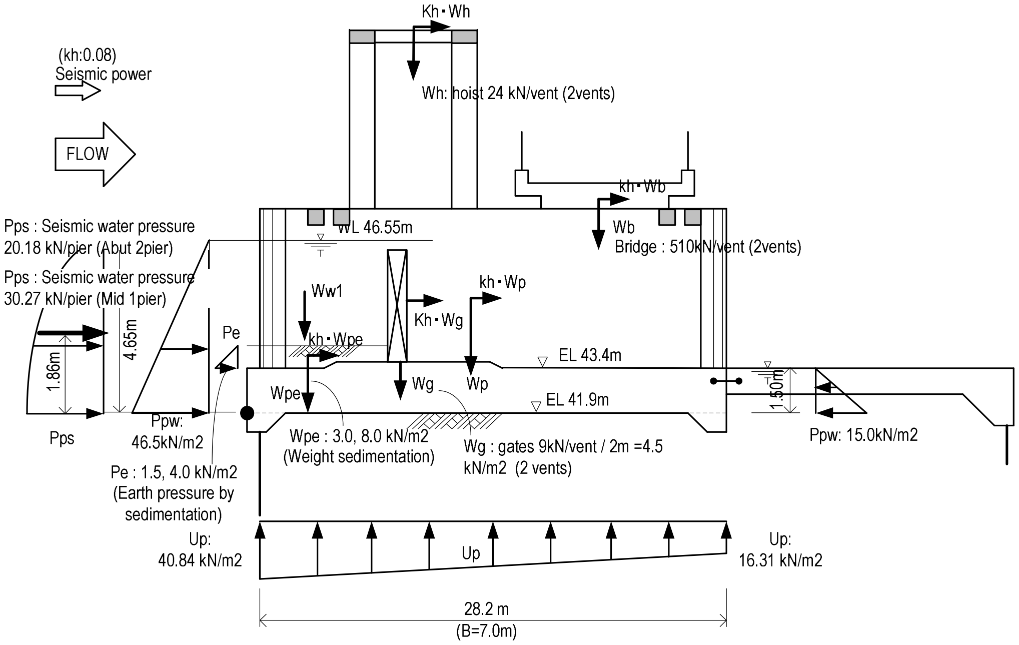

Middle pier
Abut pier
WgL : gates 9kN/vent x ½ (1piers)
WhL : hoists 24kN/vent x ½ (1piers)
WgR : gates 9kN/vent x ½ (1piers)
WhR : hoists 24kN/vent x ½ (1piers)
Free board (0.5m)
Bridge : 1260kN/vent x ½ x 2
(2 piers)
Pw1 wind :
3.6kN/m2
Wb
7.75m
Wp
EL 43.4m
EL 41.9m
WgR : gates 9kN/vent x ½ (2piers)
WhR : hoists 24kN/vent x ½ (2piers)
Free board (0.5m)
Pw1 wind :
3.6kN/m2
3.65m
EL 47.5m
Wb
Bridge : 1260kN/vent x ½
(2piers)
5.6m
Wp
EL 43.4m
EL 41.9m
Pa:1.67 kN/m2
(pedestrian)
Pa:33.57 kN/m2

Figure 11-3.10 Load condition for Badraman regulator (case 5, 6)

【CASE 7： Seism / Longitudinal direction / H.W.L. +0.25m water level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC



【CASE 8：Seism / Longitudinal direction / No water / Full OP】

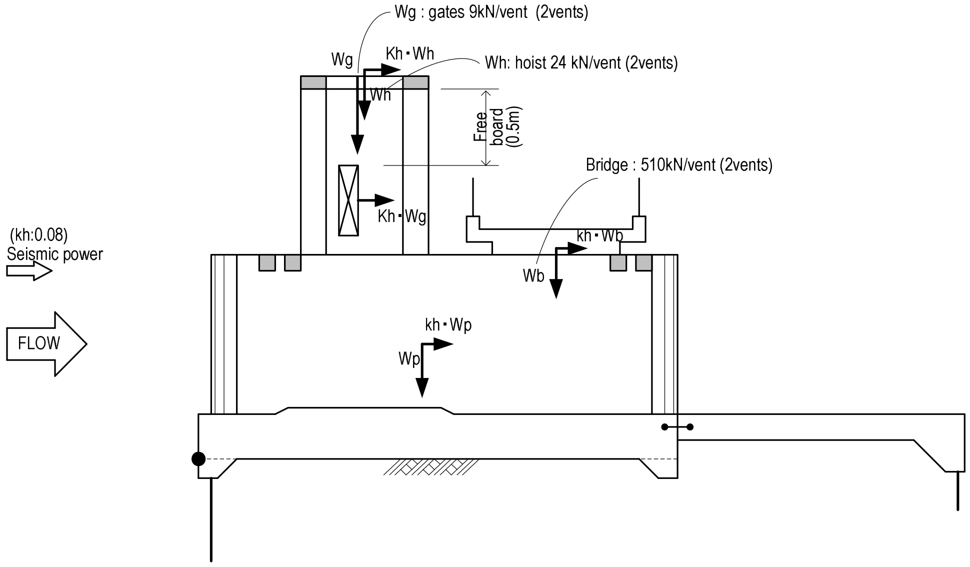
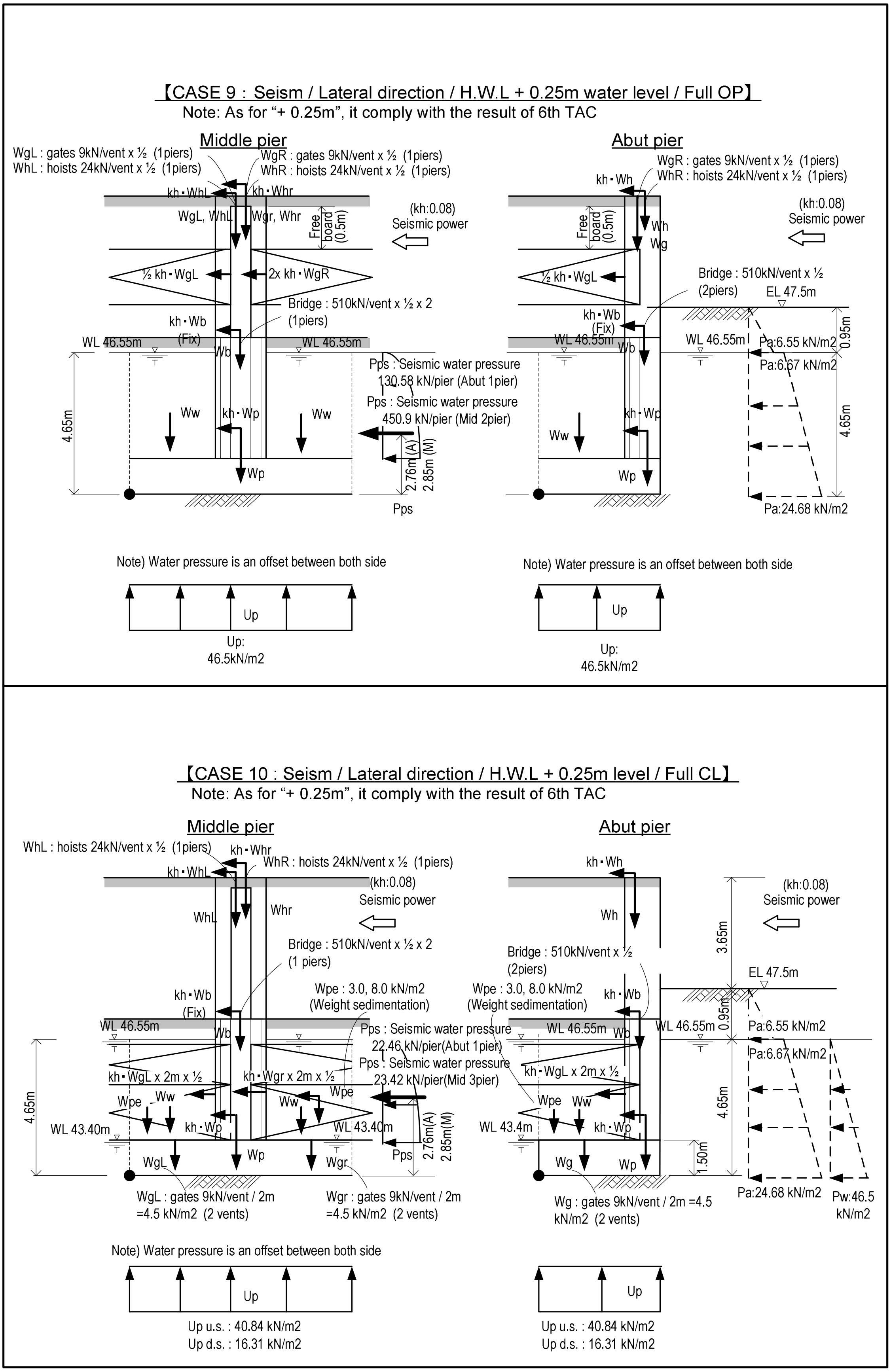

Wg : gates 9kN/vent (2vents)
Wg
Kh・Wh
Wh: hoist 24 kN/vent (2vents)
Wh
Free
board
(0.5m)
Bridge : 510kN/vent (2vents)
Kh・Wg
(kh:0.08)
Seismic power
kh・Wb
Wb
FLOW
kh・Wp
Wp

Figure11-3.11 Load condition for Badraman regulator (case 7, 8)

Badraman



【CASE 9 : Seism / Lateral direction / H.W.L + 0.25m water level / Full OP】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

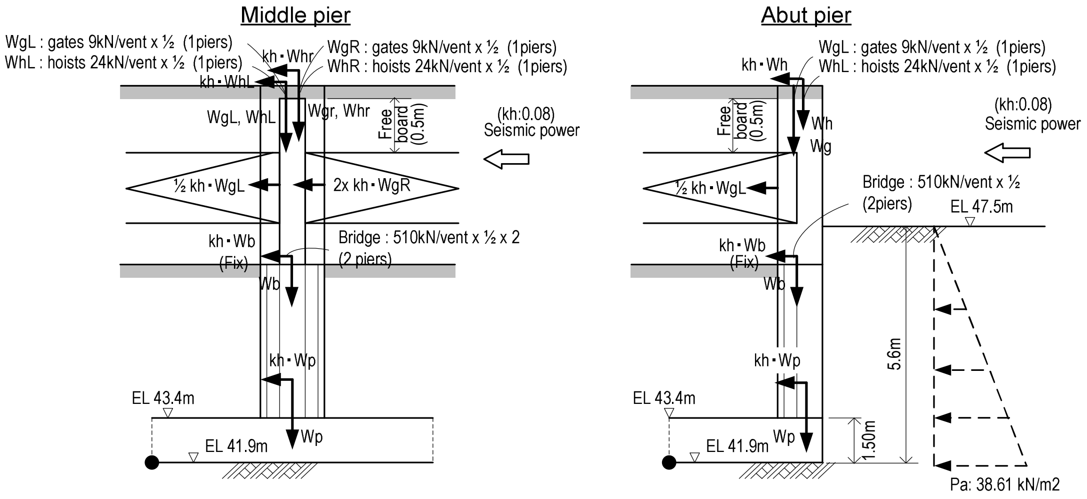
【CASE 10 : Seism / Lateral direction / H.W.L + 0.25m level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

Middle pier
Abut pier
WgL : gates 9kN/vent x ½ (1piers)
WhL : hoists 24kN/vent x ½ (1piers)
WgR : gates 9kN/vent x ½ (1piers)
WhR : hoists 24kN/vent x ½ (1piers)
kh・WhL
kh・Whr
kh・Wh
WgL, WhL
Wgr, Whr
Free board (0.5m)
(kh:0.08)
Seismic power
½ kh・WgL
2x kh・WgR
Bridge : 510kN/vent x ½ x 2
(1piers)
Bridge : 510kN/vent x ½
(2piers)
kh・Wb
(Fix)
WL 46.55m
Wb
Wh
Wg
EL 47.5m
Pa:6.55 kN/m2
Pa:6.67 kN/m2
Pa:24.68 kN/m2
0.95m
4.65m
Pps : Seismic water pressure
130.58 kN/pier (Abut 1pier)
Pps : Seismic water pressure
450.9 kN/pier (Mid 2pier)
Ww
kh・Wp
Wp
2.76m (A)
2.85m (M)
Pps
Note) Water pressure is an offset between both side
Up
Up:
46.5kN/m2
WhL : hoists 24kN/vent x ½ (1piers)
WhR : hoists 24kN/vent x ½ (1piers)
WhL
Whr
Bridge : 510kN/vent x ½ x 2
(1 piers)
Wpe : 3.0, 8.0 kN/m2
(Weight sedimentation)
Pps : Seismic water pressure
22.46 kN/pier(Abut 1pier)
Pps : Seismic water pressure
23.42 kN/pier(Mid 3pier)
kh・WgL x 2m x ½
kh・Wgr x 2m x ½
Wpe
WL 43.40m
WL 43.4m
WgL
Wgr
2.76m(A)
2.85m(M)
3.65m
1.50m
WgL : gates 9kN/vent / 2m
=4.5 kN/m2 (2 vents)
Wgr : gates 9kN/vent / 2m
=4.5 kN/m2 (2 vents)
Wg : gates 9kN/vent / 2m =4.5
kN/m2 (2 vents)
Pw:46.5
kN/m2
Up u.s. : 40.84 kN/m2
Up d.s. : 16.31 kN/m2

Figure11-3.12 Load condition for Badraman regulator (case 9, 10)

【CASE 11 : Seism / Lateral direction / No water / Full OP】


Middle pier
WgL : gates 9kN/vent x ½ (1piers)
WhL : hoists 24kN/vent x ½ (1piers)
kh・Whr
WgR : gates 9kN/vent x ½ (1piers)
WhR : hoists 24kN/vent x ½ (1piers)
kh・WhL
WgL, WhL
Wgr, Whr
Free board (0.5m)
(kh:0.08)
Seismic power
½ kh・WgL
2x kh・WgR
kh・Wb
(Fix)
Bridge : 510kN/vent x ½ x 2 (2 piers)
Wb
kh・Wp
EL 43.4m
EL 41.9m
Wp
Abut pier
kh・Wh
WgL : gates 9kN/vent x ½ (1piers)
WhL : hoists 24kN/vent x ½ (1piers)
Free board (0.5m)
Wh
Wg
(kh:0.08)
Seismic power
½ kh・WgL
Bridge : 510kN/vent x ½ (2piers)
EL 47.5m
kh・Wb
(Fix)
Wb
kh・Wp
5.6m
EL 43.4m
EL 41.9m
Wp
1.50m
Pa: 38.61 kN/m2

【CASE 12 : Seism / Longitudinal direction/ H.W.L.+0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

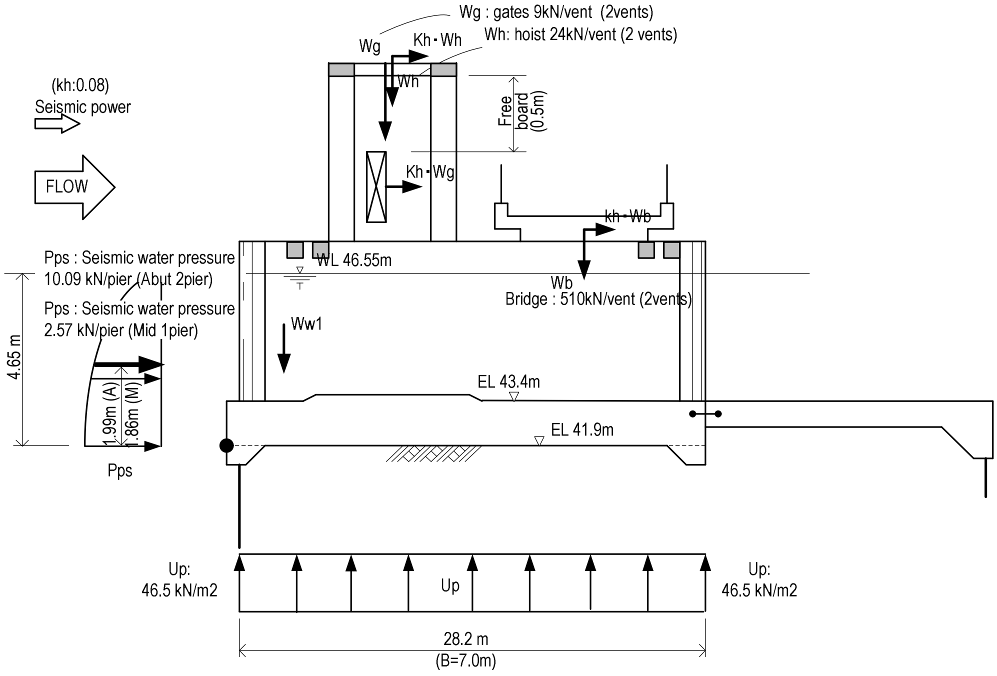

Wg : gates 9kN/vent (2vents)
Wh: hoist 24kN/vent (2 vents)
Wg
Kh・Wh
Wh
Free board (0.5m)
(kh:0.08)
Seismic power
FLOW
Kh・Wg
kh・Wb
Pps : Seismic water pressure 10.09 kN/pier (Abut 2pier)
Pps : Seismic water pressure 2.57 kN/pier (Mid 1pier)
WL 46.55m
Wb
Bridge : 510kN/vent (2vents)
Ww1
4.65 m
1.99m (A)
1.86m (M)
EL 43.4m
EL 41.9m
Pps
Up:
46.5 kN/m2
Up
Up:
46.5 kN/m2
28.2 m
(B=7.0m)

Figure11-3.13 Load condition for Badraman regulator (case 11, 12)

Badraman

【CASE 13 : / Regular / Longitudinal direction/ H.W.L.+0.25m water level / Maintenance case】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC
: One vent closed with stoplog gates and the others fully opened

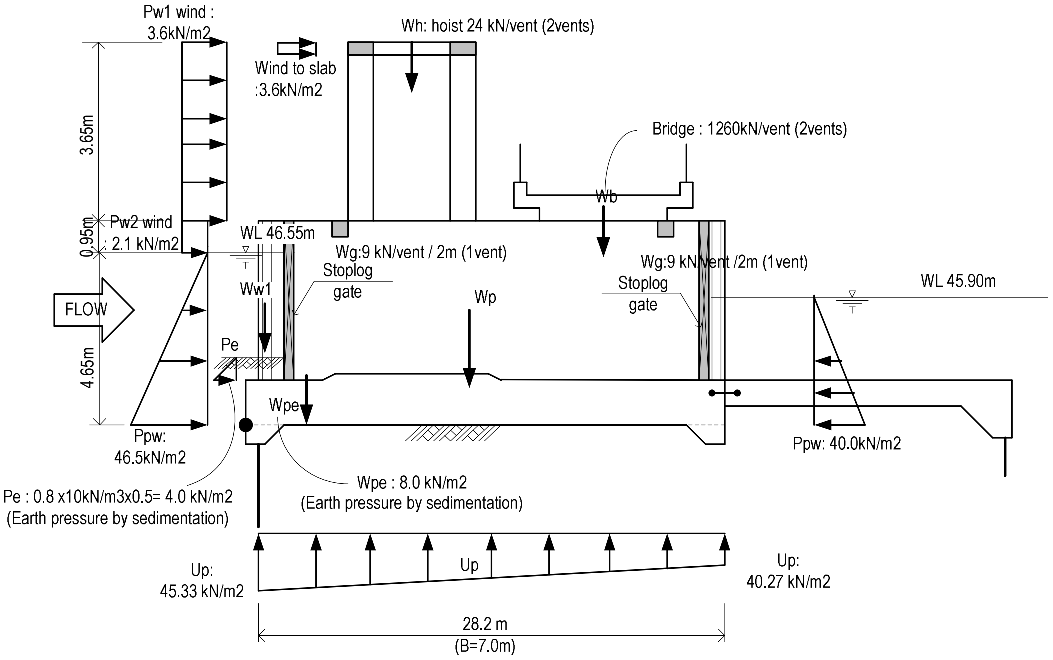
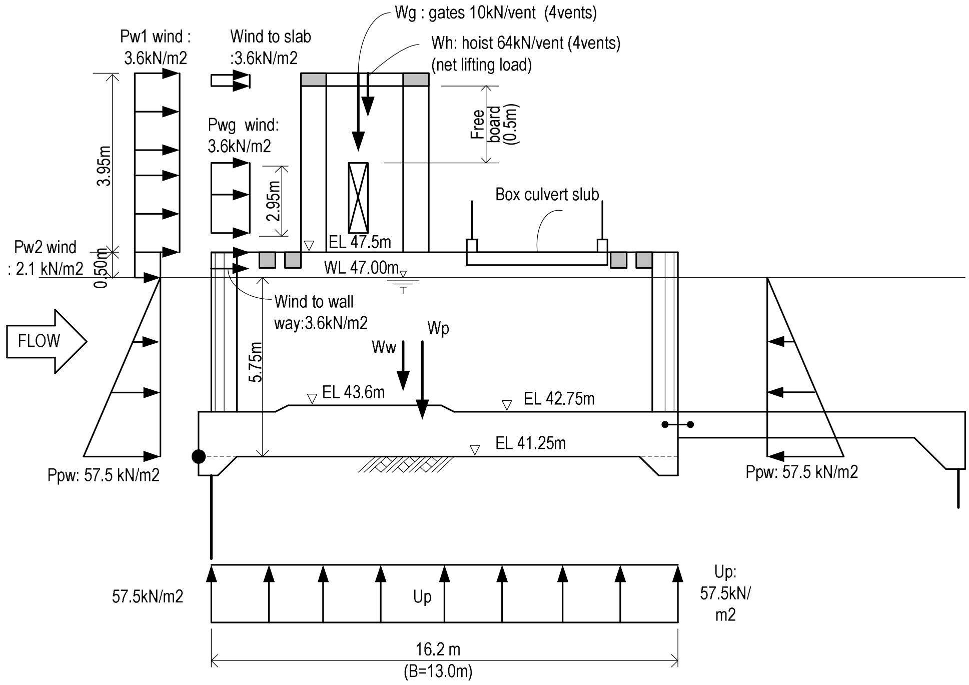


Figure11-3.14 Load condition for Badraman regulator (case 13)

【CASE 1： Regular / Longitudinal direction/ H.H.W.L. / Full OP】



【CASE 2：Regular / Longitudinal direction/ H.WL+0.25m water level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

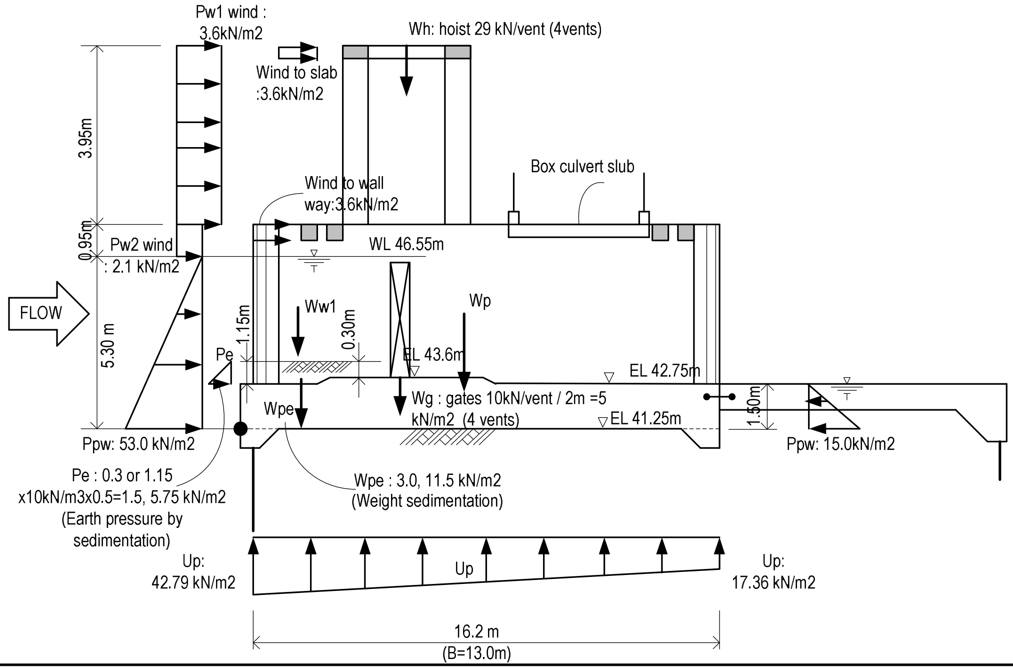
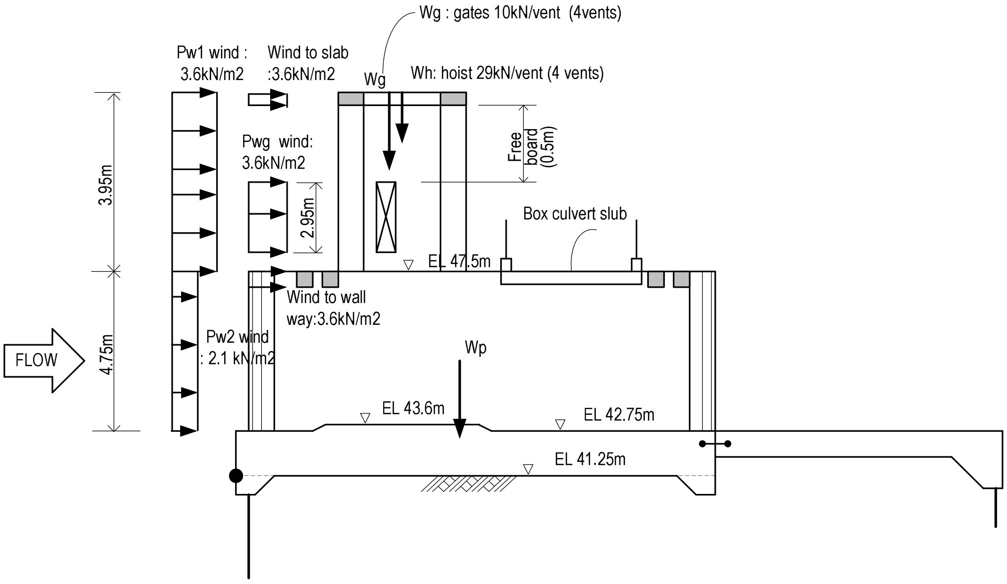


Figure11-3.15 Load condition for Abo Gabal regulator (case 1, 2)

【CASE 3 : Regular / Longitudinal direction/ No. water / Full OP】



【CASE 4 : Regular / Lateral direction / H.W.L. +0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

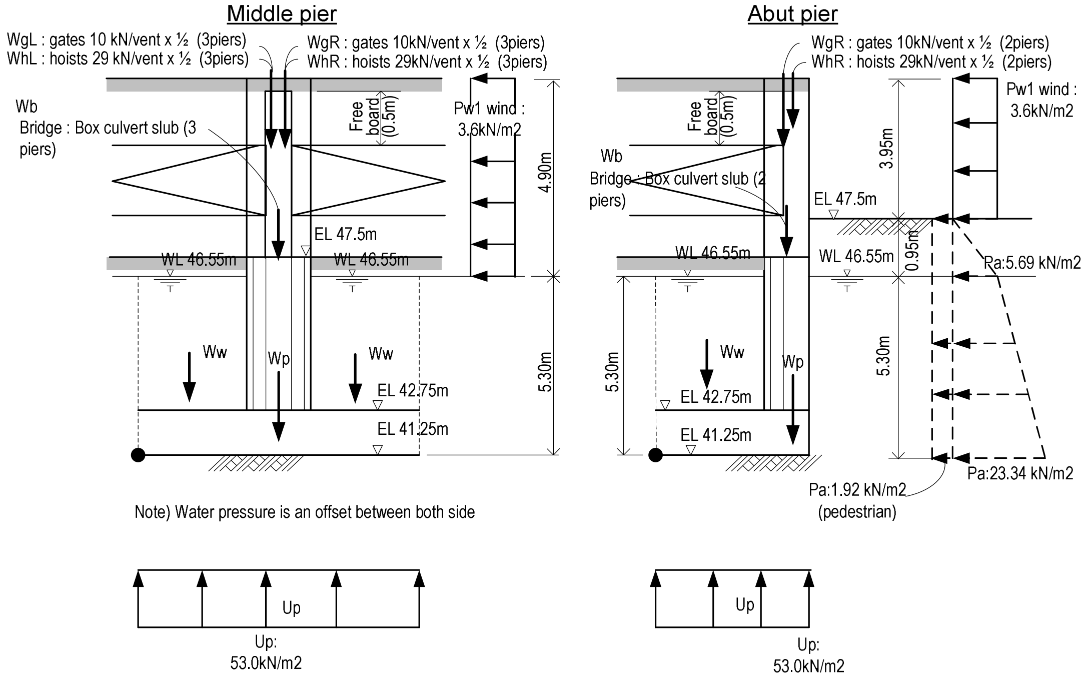
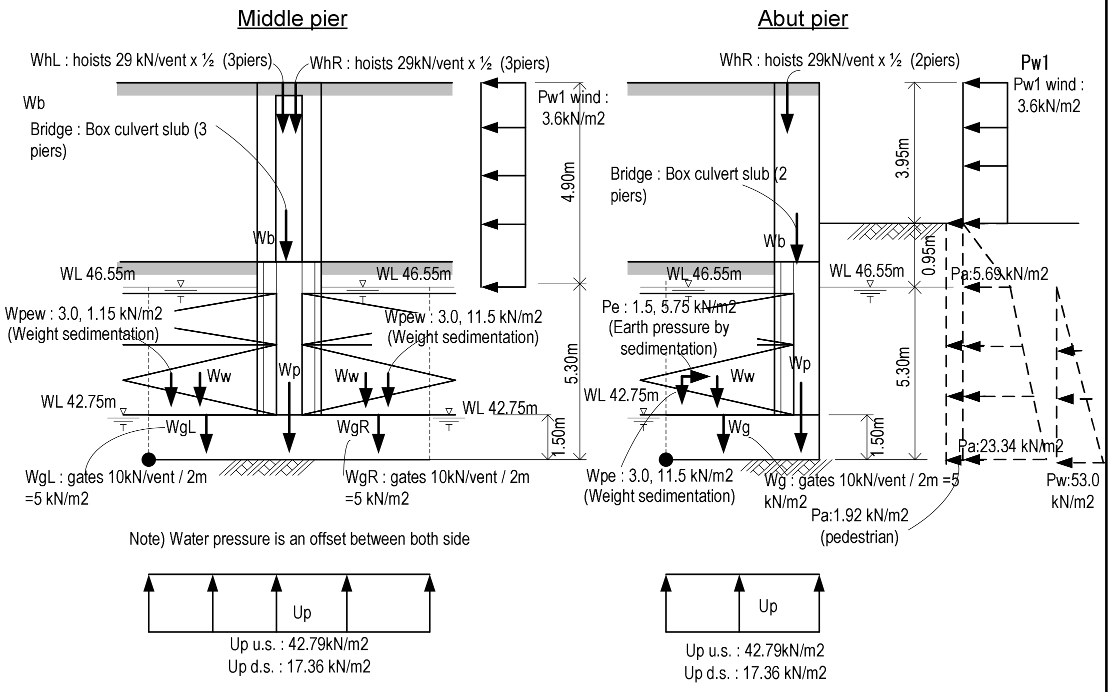

Middle pier
Abut pier
WgL : gates 10 kN/vent x ½ (3piers)
WhL : hoists 29 kN/vent x ½ (3piers)
WgR : gates 10kN/vent x ½ (3piers)
WhR : hoists 29kN/vent x ½ (3piers)
Wb
Bridge : Box culvert slub (3 piers)
Free board (0.5m)
Pw1 wind : 3.6kN/m2
4.90m
EL 47.5m
WL 46.55m
WL 46.55m
Ww
Wp
Ww
EL 42.75m
EL 41.25m
5.30m
Note) Water pressure is an offset between both side
Up
Up: 53.0kN/m2
WgR : gates 10kN/vent x ½ (2piers)
WhR : hoists 29kN/vent x ½ (2piers)
Pw1 wind : 3.6kN/m2
Free board (0.5m)
Wb
Bridge : Box culvert slub (2 piers)
3.95m
EL 47.5m
WL 46.55m
WL 46.55m
0.95m
Pa:5.69 kN/m2
5.30m
Ww
Wp
5.30m
EL 42.75m
EL 41.25m
Pa:1.92 kN/m2 (pedestrian)
Pa:23.34 kN/m2
Up
Up: 53.0kN/m2

Figure11-3.16 Load condition for Abo Gabal regulator (case 3, 4)

【CASE 5：Regular / Lateral direction/ H.W.L.+0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC


Middle pier
Abut pier
WhL : hoists 29 kN/vent x ½ (3piers)
WhR : hoists 29kN/vent x ½ (3piers)
Wb
Bridge : Box culvert slub (3 piers)
Pw1 wind : 3.6kN/m2
4.90m
Wb
WL 46.55m
WL 46.55m
Wpew : 3.0, 1.15 kN/m2 (Weight sedimentation)
Wpew : 3.0, 11.5 kN/m2 (Weight sedimentation)
Ww
Wp
Ww
WL 42.75m
WL 42.75m
WgL
WgR
5.30m
1.50m
WgL : gates 10kN/vent / 2m =5 kN/m2
WgR : gates 10kN/vent / 2m =5 kN/m2
Note) Water pressure is an offset between both side
Up
Up u.s. : 42.79kN/m2
Up d.s. : 17.36 kN/m2
WhR : hoists 29kN/vent x ½ (2piers)
Pw1
Pw1 wind : 3.6kN/m2
Bridge : Box culvert slub (2 piers)
3.95m
Wb
0.95m
WL 46.55m
WL 46.55m
Pa:5.69 kN/m2
Pe : 1.5, 5.75 kN/m2 (Earth pressure by sedimentation)
Ww
Wp
WL 42.75m
Wg
5.30m
1.50m
Pa:23.34 kN/m2
Wpe : 3.0, 11.5 kN/m2 (Weight sedimentation)
Wg : gates 10kN/vent / 2m =5 kN/m2
Pa:1.92 kN/m2 (pedestrian)
Pw:53.0 kN/m2
Up
Up u.s. : 42.79kN/m2
Up d.s. : 17.36 kN/m2

【CASE 6：Regular / Lateral direction / No water / Full OP】

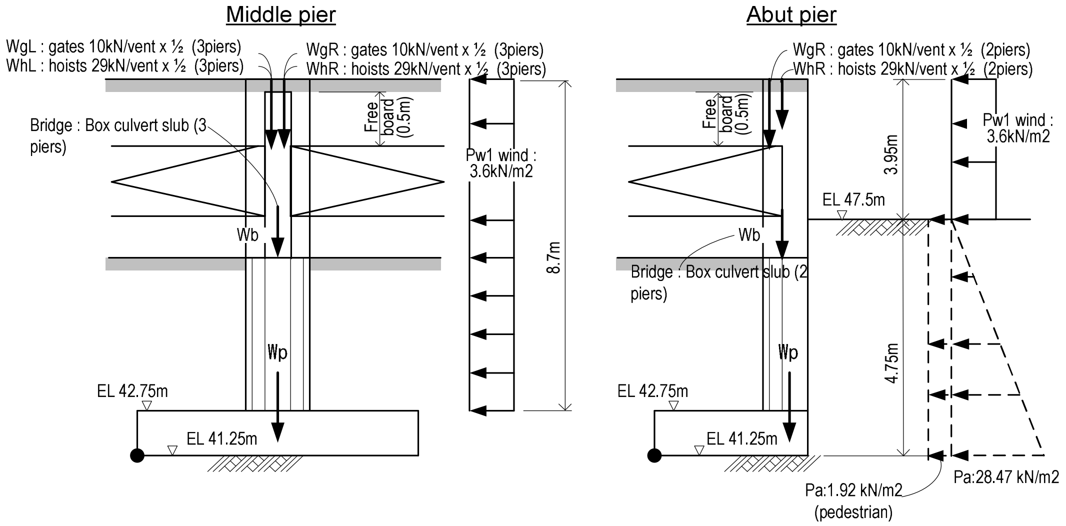
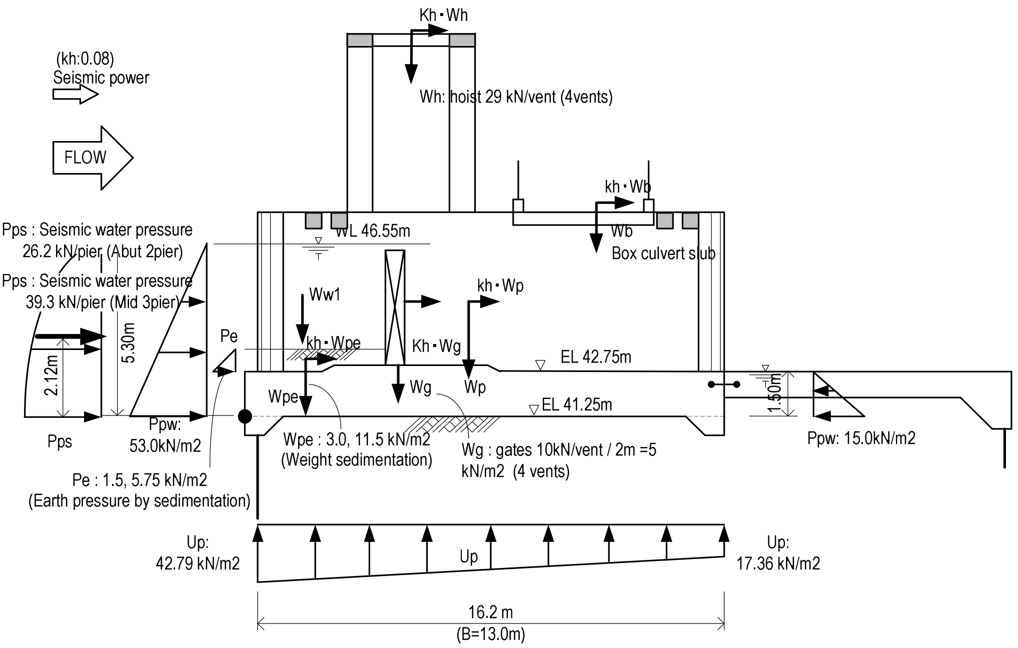

Middle pier
Abut pier
WgL : gates 10kN/vent x ½ (3piers)
WhL : hoists 29kN/vent x ½ (3piers)
WgR : gates 10kN/vent x ½ (3piers)
WhR : hoists 29kN/vent x ½ (3piers)
Bridge : Box culvert slub (3 piers)
Free board (0.5m)
Pw1 wind : 3.6kN/m2
Wb
8.7m
Wp
EL 42.75m
EL 41.25m
WgR : gates 10kN/vent x ½ (2piers)
WhR : hoists 29kN/vent x ½ (2piers)
Free board (0.5m)
3.95m
Pw1 wind : 3.6kN/m2
EL 47.5m
Wb
Bridge : Box culvert slub (2 piers)
Wp
4.75m
EL 42.75m
EL 41.25m
Pa:1.92 kN/m2 (pedestrian)
Pa:28.47 kN/m2

Figure11-3.17 Load condition for Abo Gabal regulator (case 5, 6)

【CASE 7 : Seism / Longitudinal direction / H.W.L. +0.25m water level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC



【CASE 8 : Seism / Longitudinal direction / No water / Full OP】

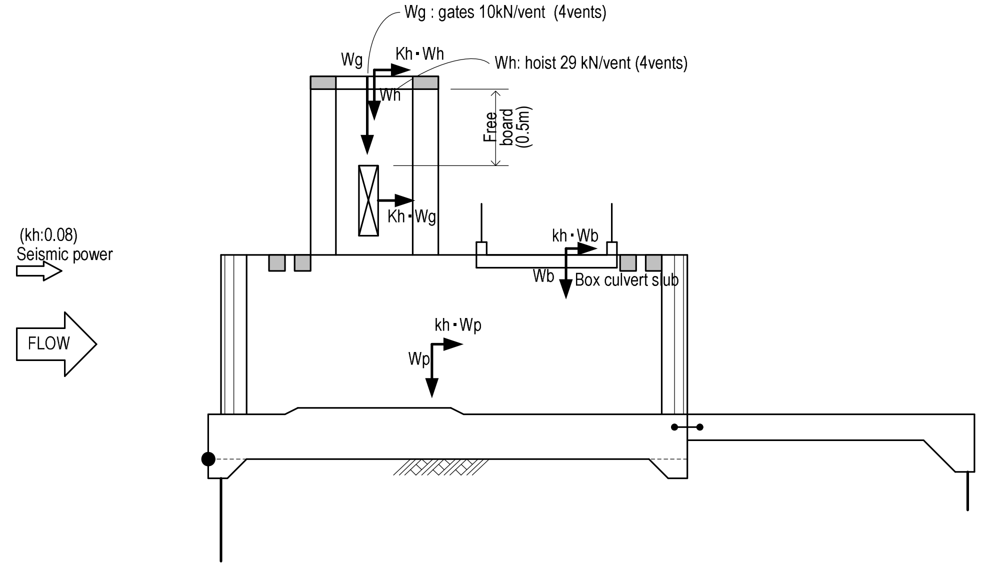
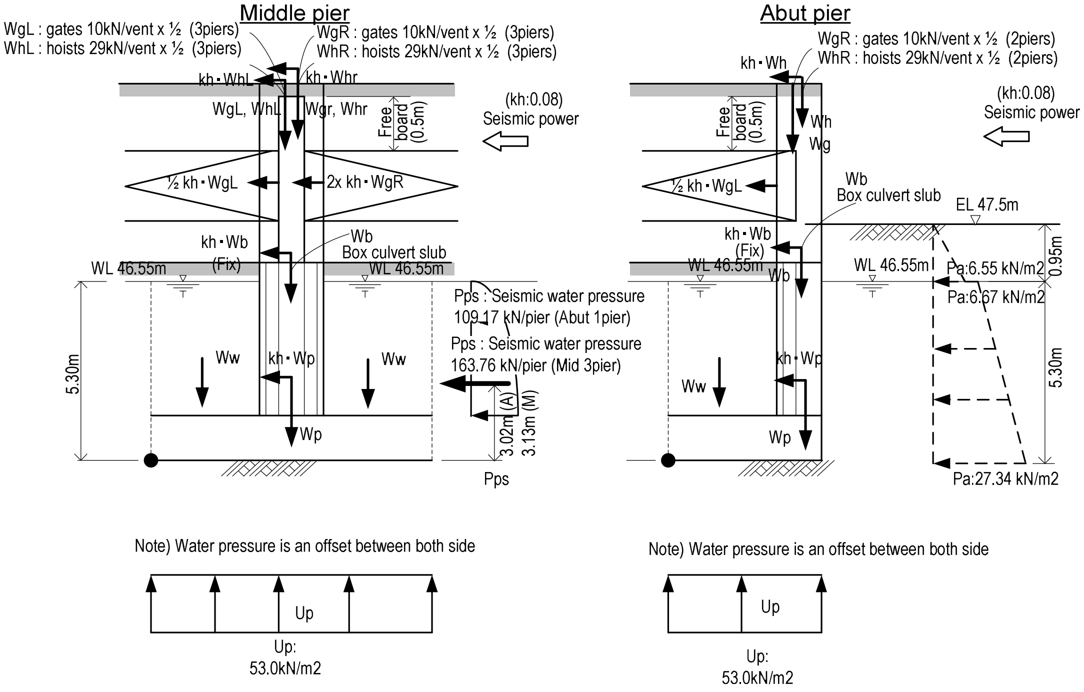


Figure11-3.18 Load condition for Abo Gabal regulator (case 7, 8)

【CASE 9 : Seism / Lateral direction / H.W.L + 0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC


Middle pier
WgL : gates 10kN/vent x ½ (3piers)
WhL : hoists 29kN/vent x ½ (3piers)
WgR : gates 10kN/vent x ½ (3piers)
WhR : hoists 29kN/vent x ½ (3piers)
kh･WhL
kh･Whr
WgL, WhL
Wgr, Whr
Free board (0.5m)
(kh:0.08)
Seismic power
½ kh･WgL
2x kh･WgR
kh･Wb
(Fix)
Wb
Box culvert slub
WL 46.55m
WL 46.55m
Pps : Seismic water pressure
109.17 kN/pier (Abut 1pier)
Pps : Seismic water pressure
163.76 kN/pier (Mid 3pier)
5.30m
Ww
kh･Wp
Ww
Wp
3.02m (A)
3.13m (M)
Pps
Note) Water pressure is an offset between both side
Up
Up:
53.0kN/m2
Abut pier
kh･Wh
WgR : gates 10kN/vent x ½ (2piers)
WhR : hoists 29kN/vent x ½ (2piers)
Free board (0.5m)
Wh
Wg
(kh:0.08)
Seismic power
½ kh･WgL
Wb
Box culvert slub
EL 47.5m
kh･Wb
(Fix)
WL 46.55m
Wb
WL 46.55m
Pa:6.55 kN/m2
Pa:6.67 kN/m2
0.95m
5.30m
kh･Wp
Ww
Wp
Pa:27.34 kN/m2
Note) Water pressure is an offset between both side
Up
Up:
53.0kN/m2

【CASE 10 : Seism / Lateral direction / H.W.L + 0.25m level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

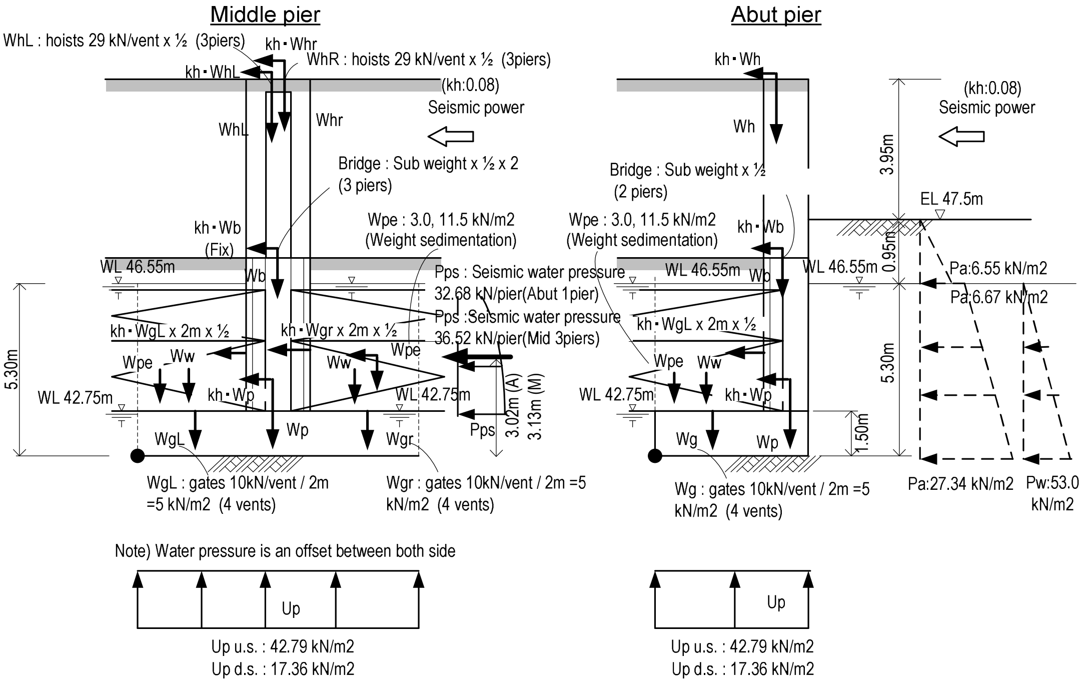
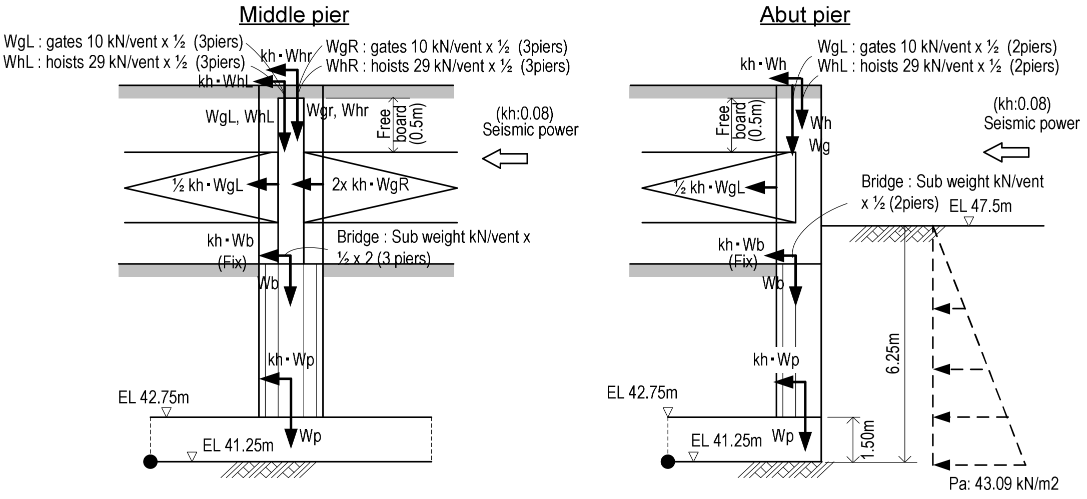


Figure11-3.19 Load condition for Abo Gabal regulator (case 9, 10)

【CASE 11 : Seism / Lateral direction / No water / Full OP】


Middle pier
WgL : gates 10 kN/vent x ½ (3piers)
WhL : hoists 29 kN/vent x ½ (3piers)
kh・Whr
WgR : gates 10 kN/vent x ½ (3piers)
WhR : hoists 29 kN/vent x ½ (3piers)
kh・WhL
WgL, WhL
Wgr, Whr
Free board (0.5m)
(kh:0.08)
Seismic power
½ kh・WgL
2x kh・WgR
kh・Wb
(Fix)
Bridge : Sub weight kN/vent x ½ x 2 (3 piers)
Wb
kh・Wp
EL 42.75m
EL 41.25m
Wp
Abut pier
kh・Wh
WgL : gates 10 kN/vent x ½ (2piers)
WhL : hoists 29 kN/vent x ½ (2piers)
Free board (0.5m)
Wh
Wg
(kh:0.08)
Seismic power
½ kh・WgL
Bridge : Sub weight kN/vent x ½ (2piers)
EL 47.5m
kh・Wb
(Fix)
Wb
6.25m
kh・Wp
EL 42.75m
EL 41.25m
Wp
1.50m
Pa: 43.09 kN/m2

【CASE 12 : Seism / Longitudinal direction/ H.W.L.+0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

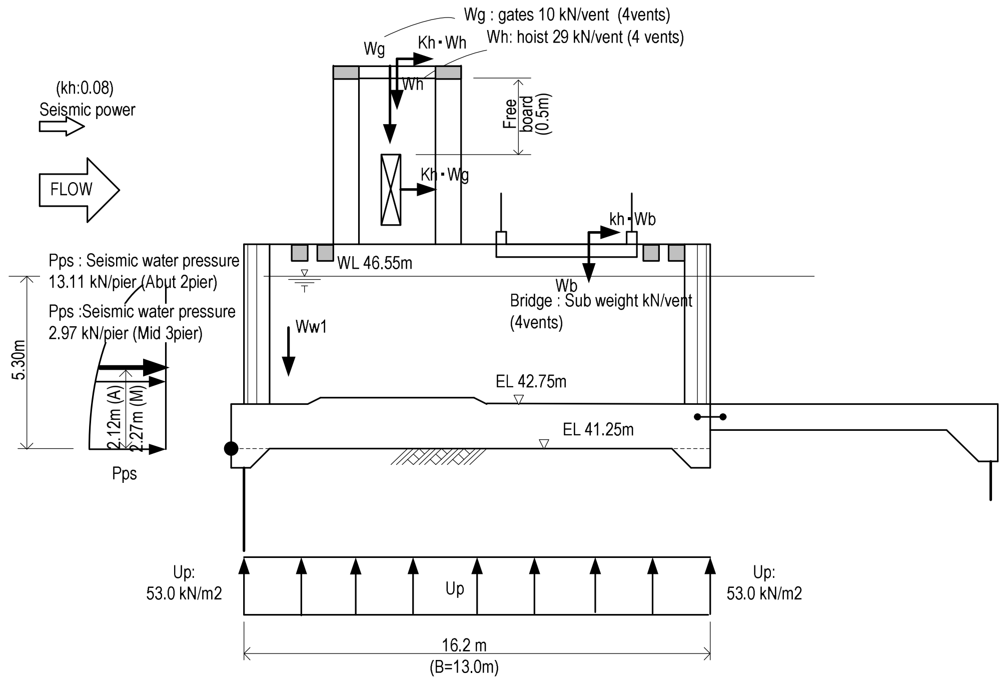

Wg : gates 10 kN/vent (4vents)
Wh: hoist 29 kN/vent (4 vents)
Wg
Kh・Wh
Wh
(kh:0.08)
Seismic power
Free board (0.5m)
FLOW
Kh・Wg
kh・Wb
Pps : Seismic water pressure 13.11 kN/pier (Abut 2pier)
Pps :Seismic water pressure 2.97 kN/pier (Mid 3pier)
WL 46.55m
Wb
Bridge : Sub weight kN/vent (4vents)
Ww1
5.30m
2.12m (A)
2.27m (M)
EL 42.75m
EL 41.25m
Pps
Up:
53.0 kN/m2
Up
Up:
53.0 kN/m2
16.2 m
(B=13.0m)

Figure11-3.20 Load condition for Abo Gabal regulator (case 11, 12)

【CASE 13 : / Regular / Longitudinal direction/ H.W.L.+0.25m water level / Maintenance case】

Note: As for "+ 0.25m", it comply with the result of 6th TAC
: One vent closed with stoplog gates and the others fully opened

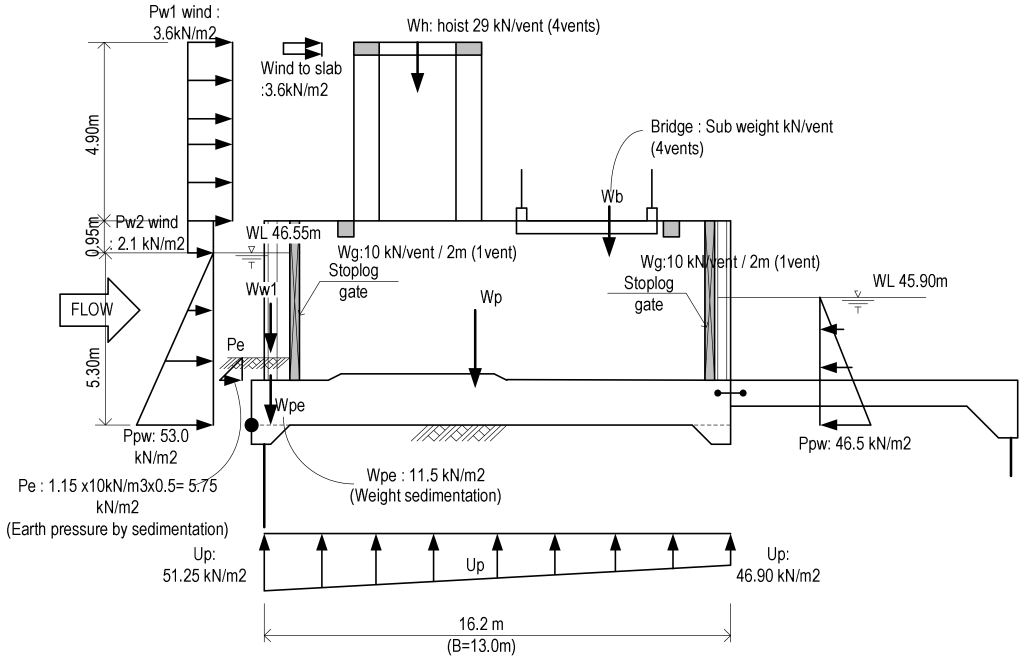
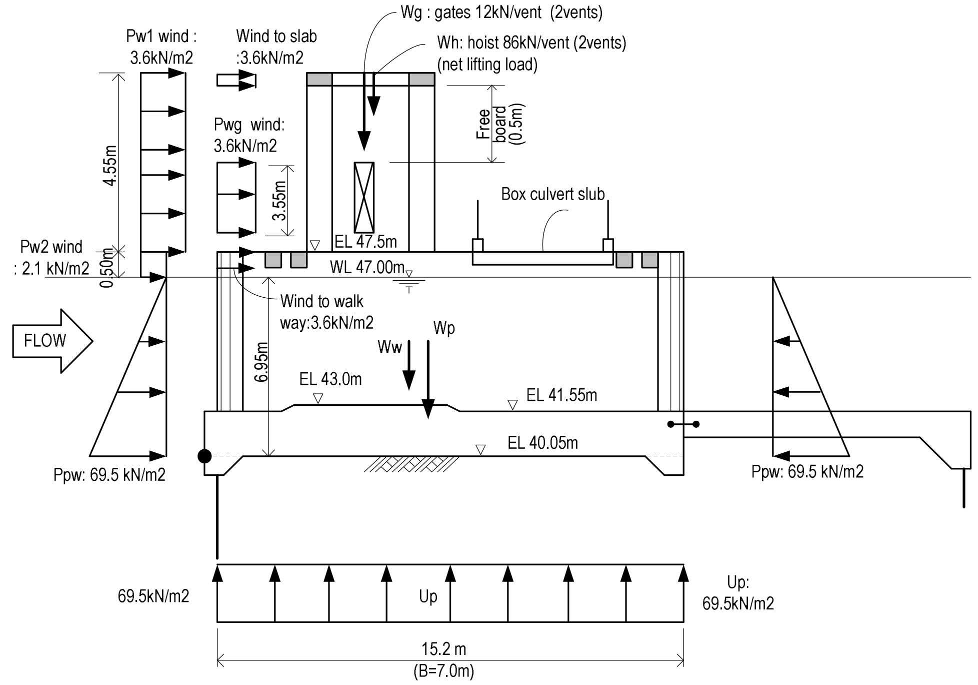


Figure11-3.21 Load condition for Abo Gabal regulator (case 13)

【CASE 1： Regular / Longitudinal direction/ H.H.W.L. / Full OP】



【CASE 2：Regular / Longitudinal direction/ H.WL+0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

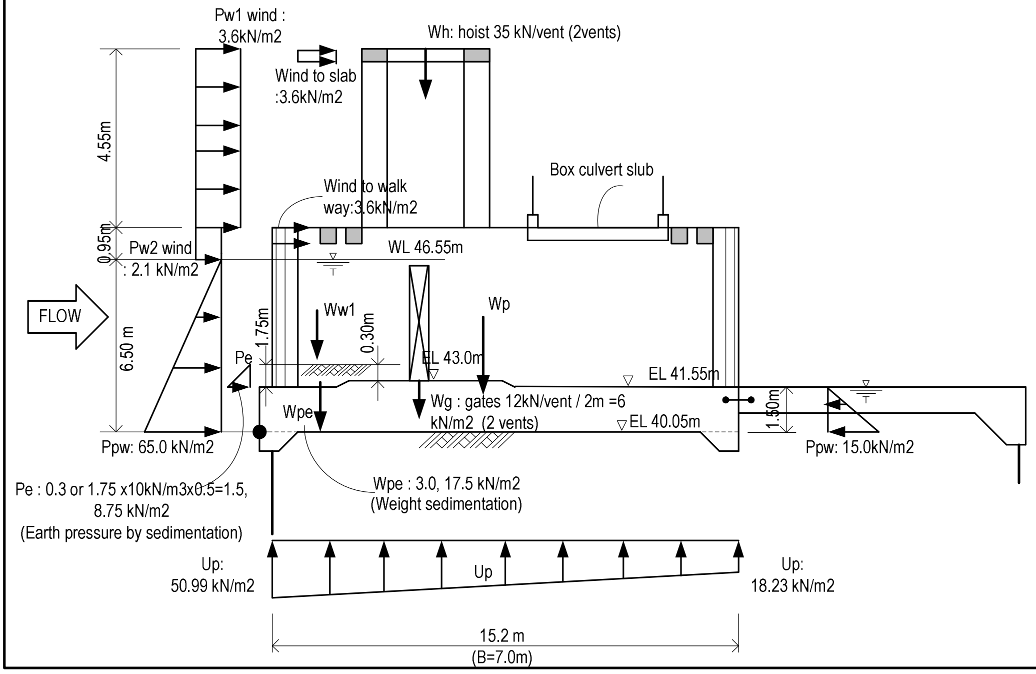
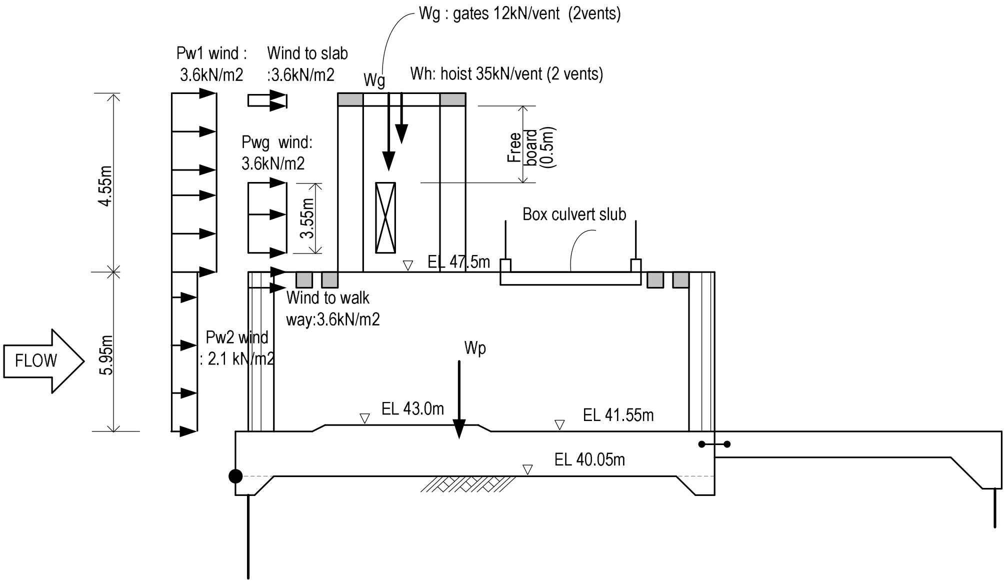


Figure11-3.22 Load condition for Sahelyia regulator (case 1, 2)

【CASE 3：Regular / Longitudinal direction/ No. water / Full OP】



【CASE 4：Regular / Lateral direction / H.W.L. +0.25m water level / Full OP】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

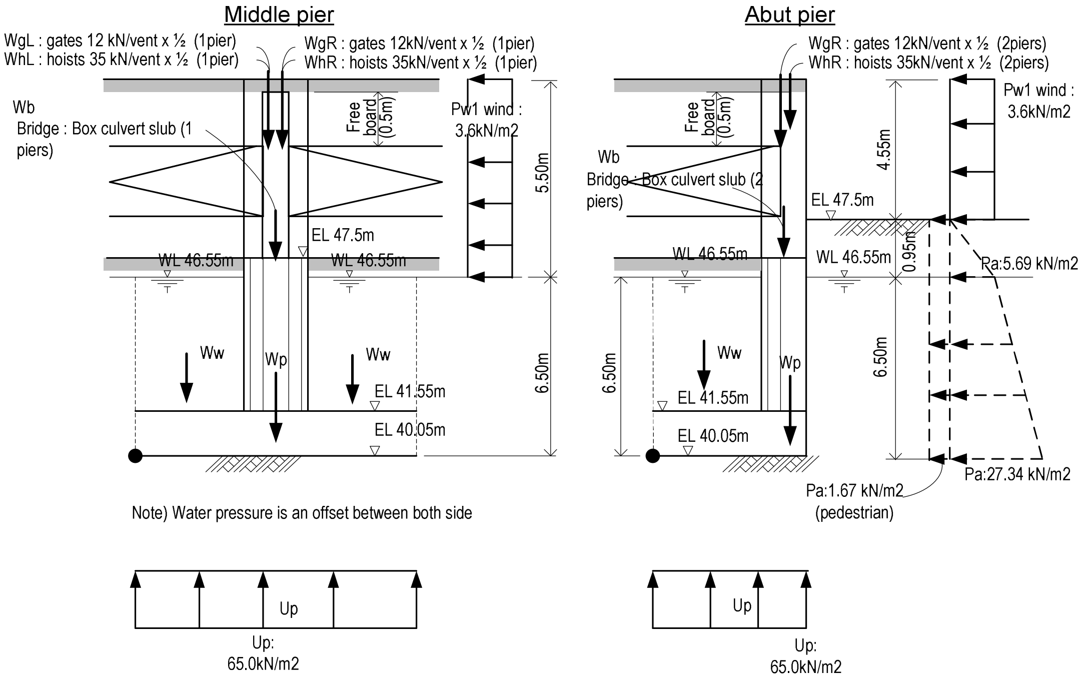
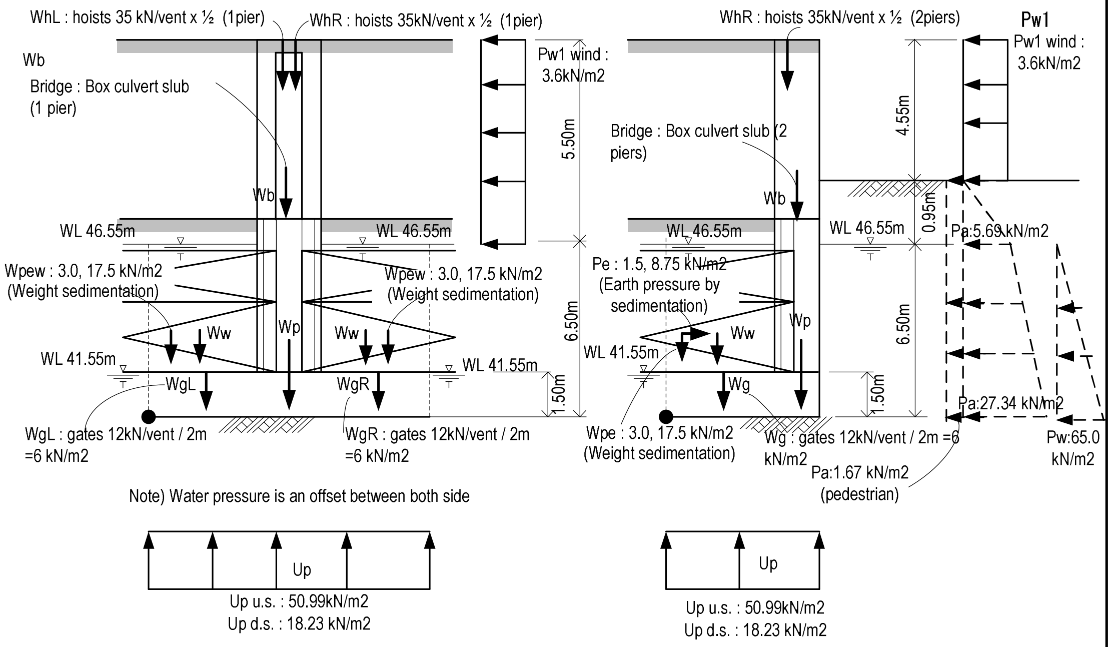

Middle pier
WgL : gates 12 kN/vent x ½ (1pier)
WhL : hoists 35 kN/vent x ½ (1pier)
WgR : gates 12kN/vent x ½ (1pier)
WhR : hoists 35kN/vent x ½ (1pier)
Wb
Bridge : Box culvert slub (1 piers)
Free board (0.5m)
Pw1 wind : 3.6kN/m2
5.50m
EL 47.5m
WL 46.55m
WL 46.55m
Ww
Wp
Ww
EL 41.55m
EL 40.05m
6.50m
Note) Water pressure is an offset between both side
Up
Up: 65.0kN/m2
Abut pier
WgR : gates 12kN/vent x ½ (2piers)
WhR : hoists 35kN/vent x ½ (2piers)
Free board (0.5m)
Pw1 wind : 3.6kN/m2
Wb
Bridge : Box culvert slub (2 piers)
4.55m
EL 47.5m
WL 46.55m
WL 46.55m
0.95m
Pa:5.69 kN/m2
6.50m
Ww
Wp
EL 41.55m
EL 40.05m
6.50m
Pa:27.34 kN/m2
Pa:1.67 kN/m2 (pedestrian)
Up
Up: 65.0kN/m2

Figure11-3.23 Load condition for Sahelyia regulator (case 3, 4)

Sahelyia

【CASE 5 : Regular / Lateral direction/ H.W.L.+0.25m water level / Full CL】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

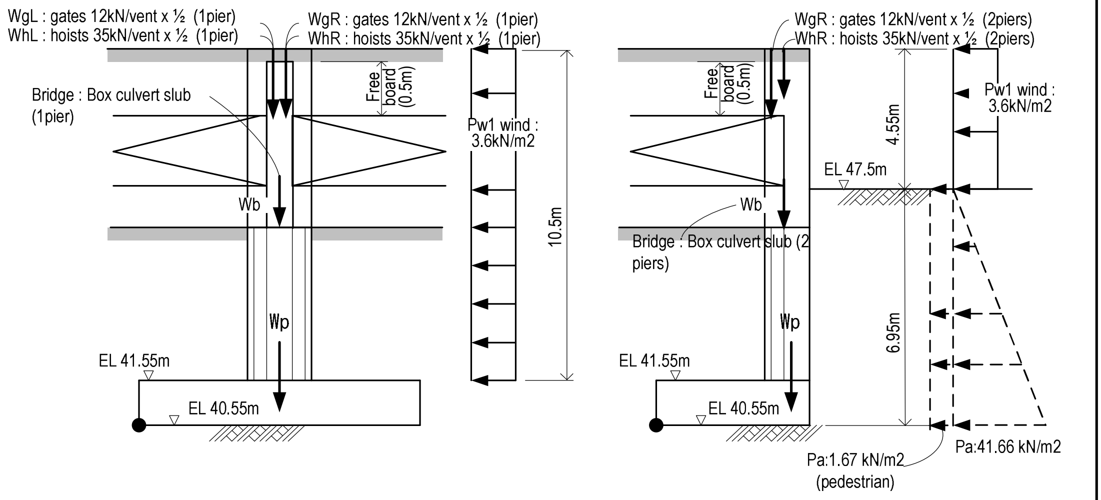


Middle pier

Abut pier

WhL : hoists 35 kN/vent x ½ (1pier)
WhR : hoists 35kN/vent x ½ (1pier)
Wb
Bridge : Box culvert slub (1 pier)
Pw1 wind : 3.6kN/m2
5.50m
Wb
WL 46.55m
WL 46.55m
Wpew : 3.0, 17.5 kN/m2 (Weight sedimentation)
Wpew : 3.0, 17.5 kN/m2 (Weight sedimentation)
Ww
Wp
Ww
WL 41.55m
WL 41.55m
WgL
WgR
6.50m
1.50m
WgL : gates 12kN/vent / 2m =6 kN/m2
WgR : gates 12kN/vent / 2m =6 kN/m2
Note) Water pressure is an offset between both side
Up
Up u.s. : 50.99kN/m2
Up d.s. : 18.23 kN/m2
WhR : hoists 35kN/vent x ½ (2piers)
Pw1
Pw1 wind : 3.6kN/m2
4.55m
Bridge : Box culvert slub (2 piers)
Wb
0.95m
WL 46.55m
WL 46.55m
Pa:5.69 kN/m2
Pe : 1.5, 8.75 kN/m2 (Earth pressure by sedimentation)
Ww
Wp
WL 41.55m
6.50m
Wg
1.50m
Pa:27.34 kN/m2
Wpe : 3.0, 17.5 kN/m2 (Weight sedimentation)
Wg : gates 12kN/vent / 2m =6 kN/m2
Pw:65.0 kN/m2
Pa:1.67 kN/m2 (pedestrian)
Up
Up u.s. : 50.99kN/m2
Up d.s. : 18.23 kN/m2

【CASE 6 : Regular / Lateral direction / No water / Full OP】



Middle pier

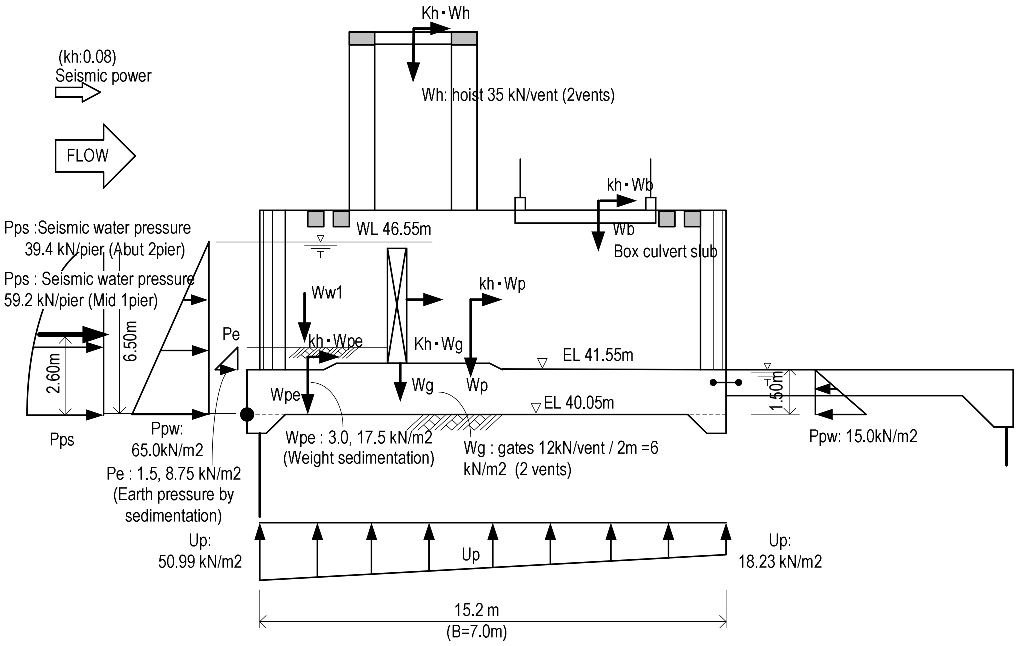
Abut pier

WgL : gates 12kN/vent x ½ (1pier)
WhL : hoists 35kN/vent x ½ (1pier)
WgR : gates 12kN/vent x ½ (1pier)
WhR : hoists 35kN/vent x ½ (1pier)
Bridge : Box culvert slub (1pier)
Free board (0.5m)
Pw1 wind : 3.6kN/m2
Wb
10.5m
Wp
EL 41.55m
EL 40.55m
WgR : gates 12kN/vent x ½ (2piers)
WhR : hoists 35kN/vent x ½ (2piers)
Free board (0.5m)
4.55m
Pw1 wind : 3.6kN/m2
EL 47.5m
Wb
Bridge : Box culvert slub (2 piers)
Wp
6.95m
EL 41.55m
EL 40.55m
Pa:1.67 kN/m2 (pedestrian)
Pa:41.66 kN/m2

Figure11-3.24 Load condition for Sahelyia regulator (case 5, 6)

【CASE 7： Seism / Longitudinal direction / H.W.L. +0.25m water level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC



【CASE 8：Seism / Longitudinal direction / No water / Full OP】

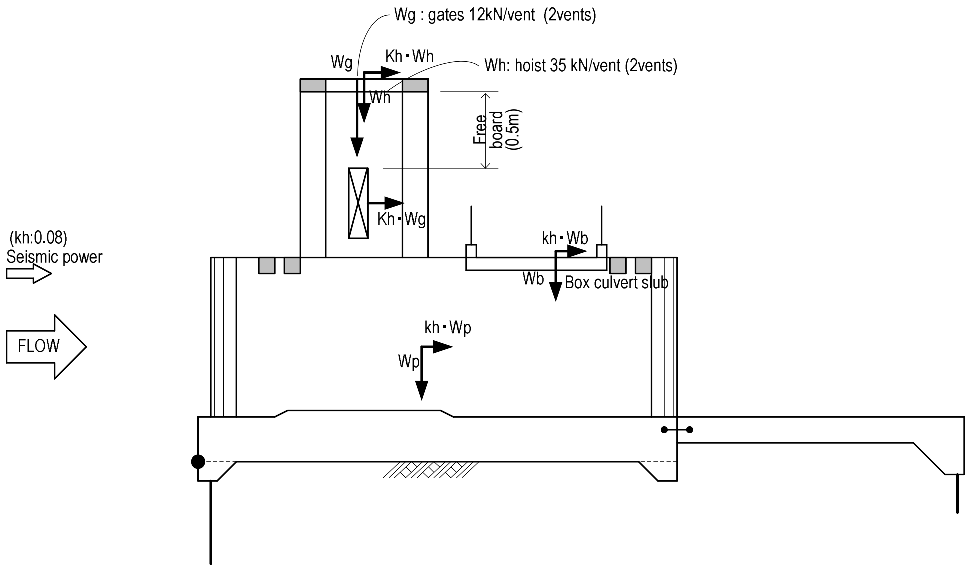
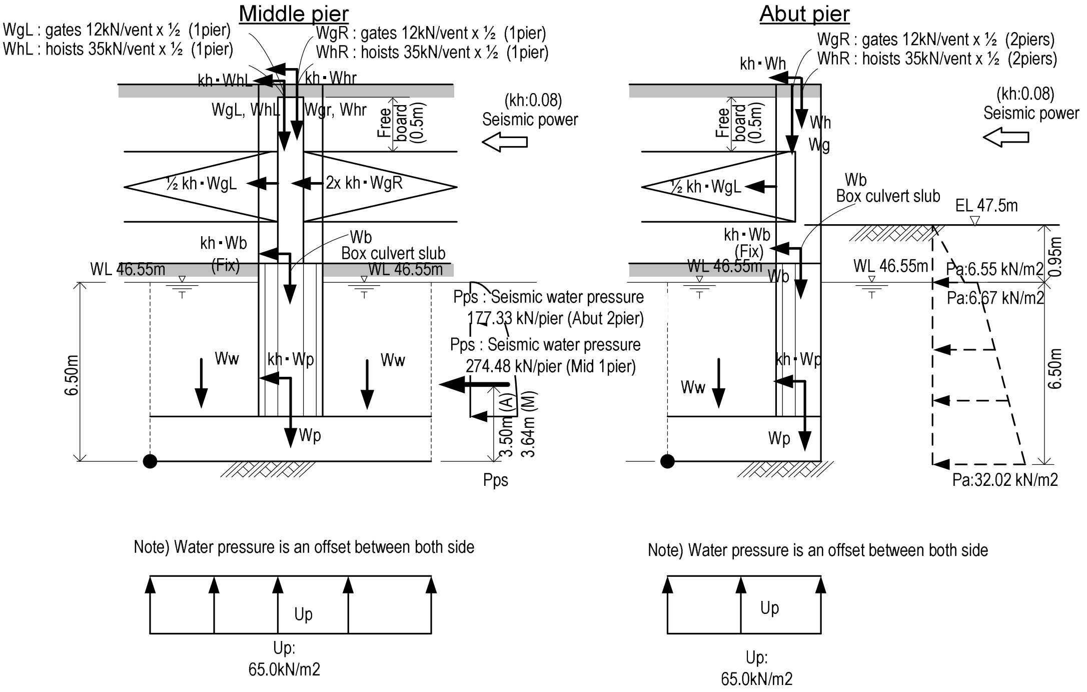


Figure11-3.25 Load condition for Sahelyia regulator (case 7, 8)

Sahelyia

【CASE 9 : Seism / Lateral direction / H.W.L + 0.25m water level / Full OP】

Note: As for "+ 0.25m", it comply with the result of 6th TAC


Middle pier
WgL : gates 12kN/vent x ½ (1pier)
WhL : hoists 35kN/vent x ½ (1pier)
WgR : gates 12kN/vent x ½ (1pier)
WhR : hoists 35kN/vent x ½ (1pier)
kh･WhL
kh･Whr
WgL, WhL
Wgr, Whr
Free board (0.5m)
(kh:0.08)
Seismic power
½ kh･WgL
2x kh･WgR
kh･Wb
(Fix)
Wb
Box culvert slub
WL 46.55m
WL 46.55m
Pps : Seismic water pressure
177.33 kN/pier (Abut 2pier)
Pps : Seismic water pressure
274.48 kN/pier (Mid 1pier)
6.50m
Ww
kh･Wp
Ww
Wp
3.50m (A)
3.64m (M)
Pps
Abut pier
WgR : gates 12kN/vent x ½ (2piers)
WhR : hoists 35kN/vent x ½ (2piers)
kh･Wh
Free board (0.5m)
Wh
Wg
(kh:0.08)
Seismic power
½ kh･WgL
Wb
Box culvert slub
EL 47.5m
kh･Wb
(Fix)
WL 46.55m
Wb
WL 46.55m
Pa:6.55 kN/m2
Pa:6.67 kN/m2
0.95m
kh･Wp
Ww
Wp
6.50m
Pa:32.02 kN/m2
Note) Water pressure is an offset between both side
Up
Up:
65.0kN/m2
Note) Water pressure is an offset between both side
Up
Up:
65.0kN/m2

【CASE 10 : Seism / Lateral direction / H.W.L + 0.25m level / Full CL】

Note: As for "+ 0.25m", it comply with the result of 6th TAC

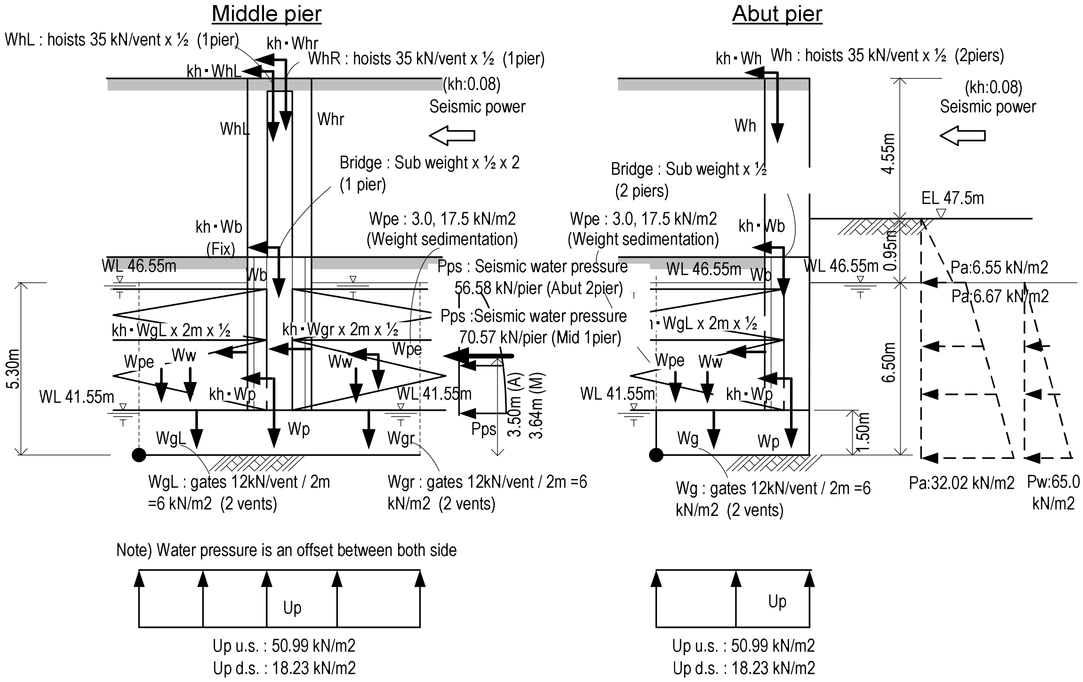
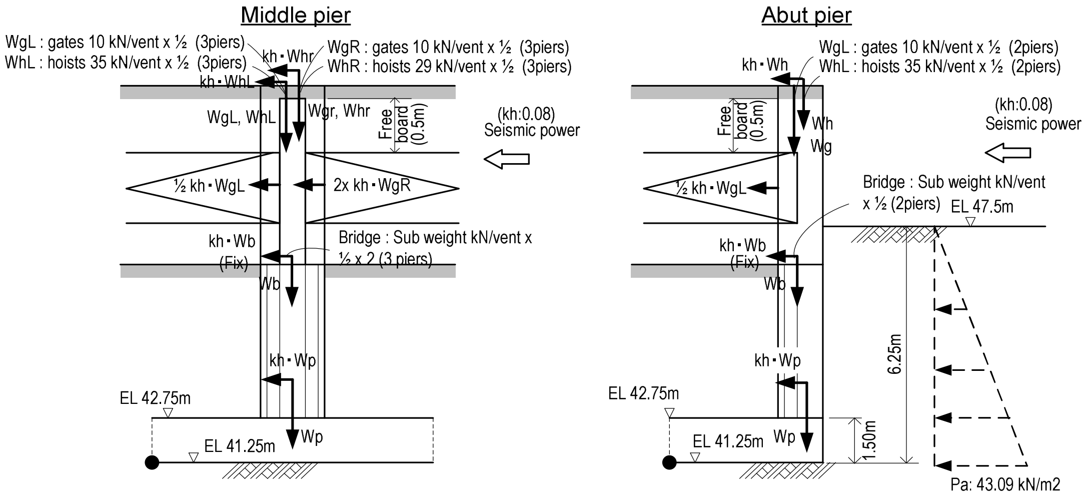


Figure11-3.26 Load condition for Sahelyia regulator (case 9, 10)

【CASE 11：Seism / Lateral direction / No water / Full OP】


Middle pier
WgL : gates 10 kN/vent x ½ (3piers)
WhL : hoists 35 kN/vent x ½ (3piers)
kh・Whr
WgR : gates 10 kN/vent x ½ (3piers)
WhR : hoists 29 kN/vent x ½ (3piers)
kh・WhL
WgL, WhL
Wgr, Whr
Free board (0.5m)
(kh:0.08)
Seismic power
½ kh・WgL
2x kh・WgR
kh・Wb
(Fix)
Bridge : Sub weight kN/vent x ½ x 2 (3 piers)
Wb
kh・Wp
EL 42.75m
EL 41.25m
Wp
Abut pier
kh・Wh
WgL : gates 10 kN/vent x ½ (2piers)
WhL : hoists 35 kN/vent x ½ (2piers)
Free board (0.5m)
Wh
Wg
(kh:0.08)
Seismic power
½ kh・WgL
Bridge : Sub weight kN/vent x ½ (2piers)
EL 47.5m
kh・Wb
(Fix)
Wb
6.25m
kh・Wp
EL 42.75m
EL 41.25m
Wp
1.50m
Pa: 43.09 kN/m2

【CASE 12：Seism / Longitudinal direction/ H.W.L.+0.25m water level / Full OP】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC

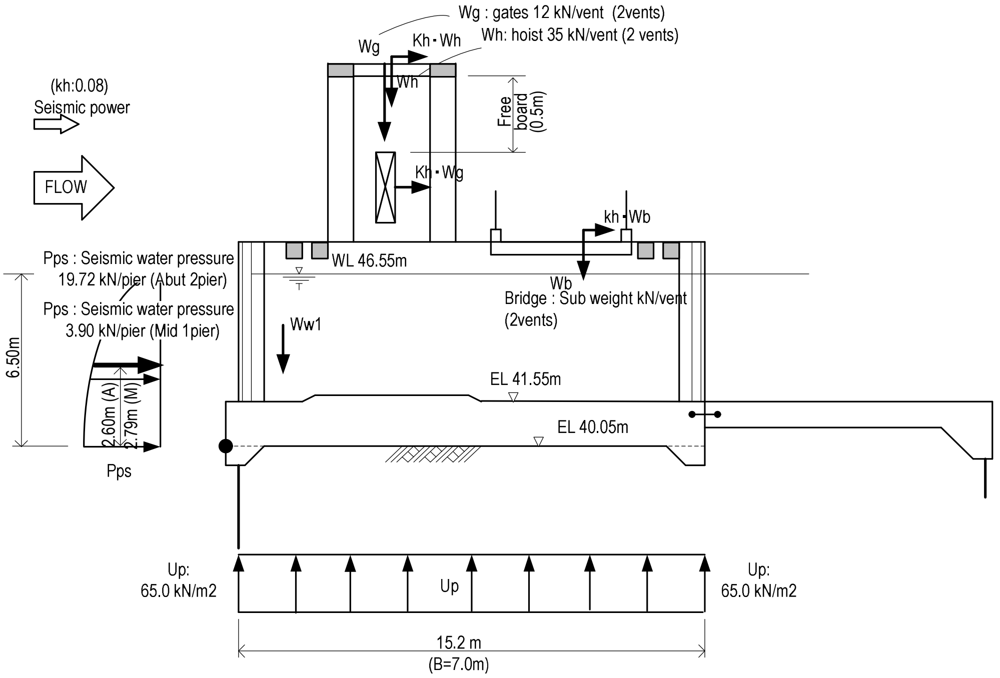

Wg : gates 12 kN/vent (2vents)
Wh: hoist 35 kN/vent (2 vents)
Wg
Kh・Wh
Wh
Free board (0.5m)
(kh:0.08)
Seismic power
FLOW
Kh・Wg
kh・Wb
Pps : Seismic water pressure 19.72 kN/pier (Abut 2pier)
Pps : Seismic water pressure 3.90 kN/pier (Mid 1pier)
WL 46.55m
Wb
Bridge : Sub weight kN/vent (2vents)
Ww1
6.50m
EL 41.55m
EL 40.05m
2.60m (A)
2.79m (M)
Pps
Up:
65.0 kN/m2
Up
Up:
65.0 kN/m2
15.2 m
(B=7.0m)

Figure11-3.27 Load condition for Sahelyia regulator (case 11, 12)

Sahelyia

【CASE 13 : / Regular / Longitudinal direction/ H.W.L.+0.25m water level / Maintenance case】

Note: As for “+ 0.25m”, it comply with the result of 6th TAC
: One vent closed with stoplog gates and the others fully opened

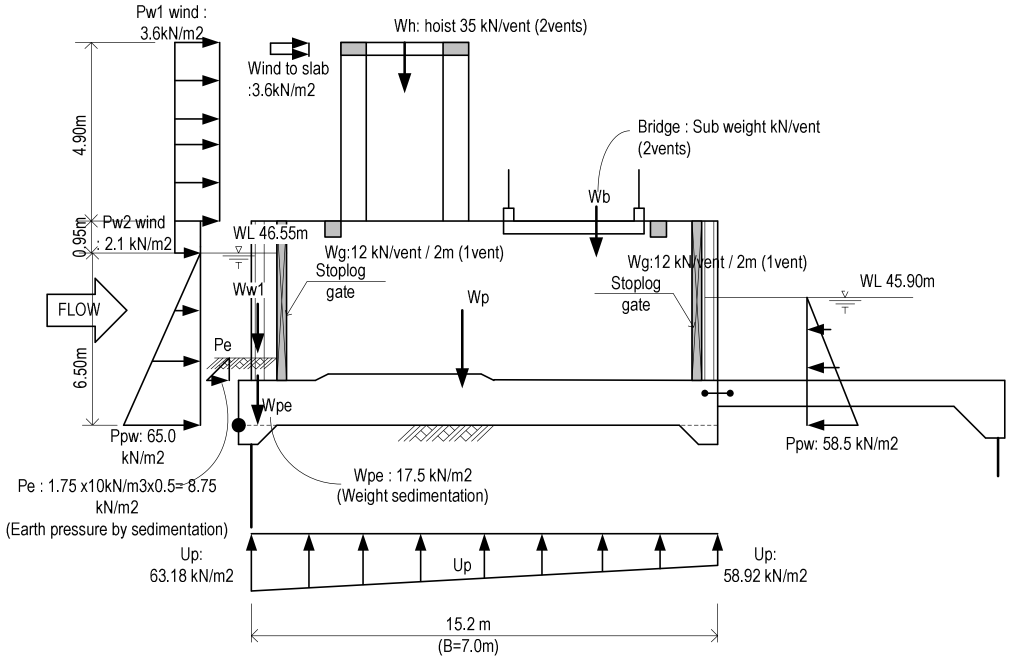


Figure11-3.28 Load condition for Sahelyia regulator (case 13)

(3) Result of structural analysis

As shown on Tables 11-3.6 to 11-3.10, the necessary steel bars for each regulator are arranged for safety. The Figure below shows the image model for the frame analysis. The result of the analysis is based on this frame model.

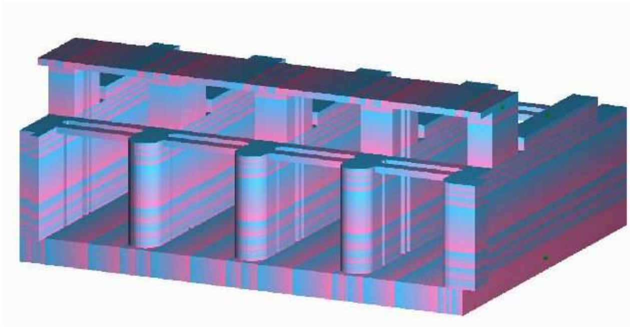
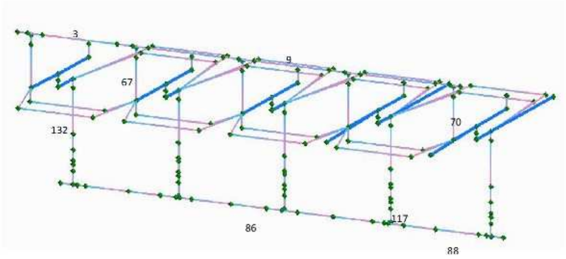
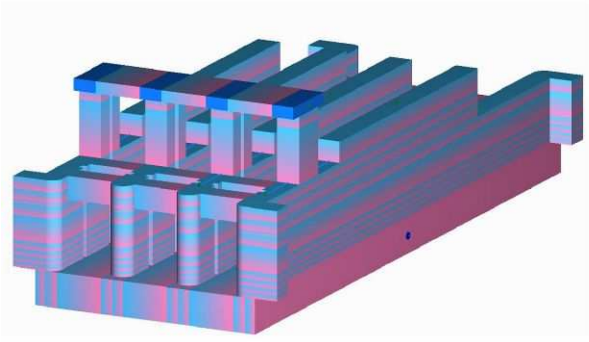
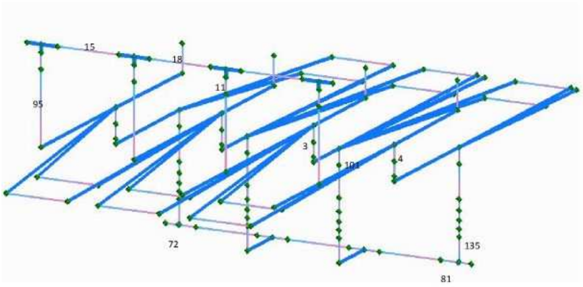
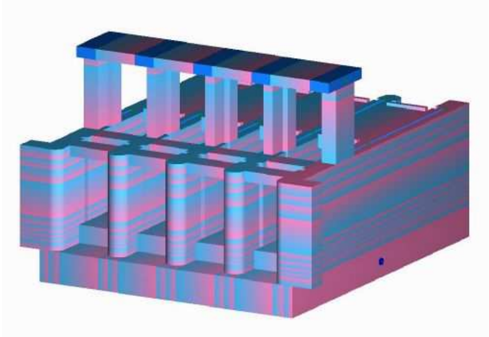
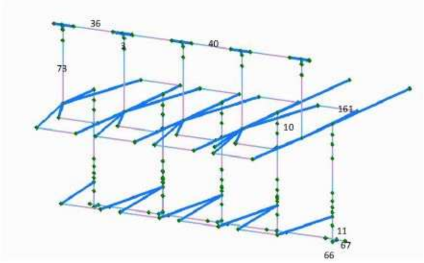
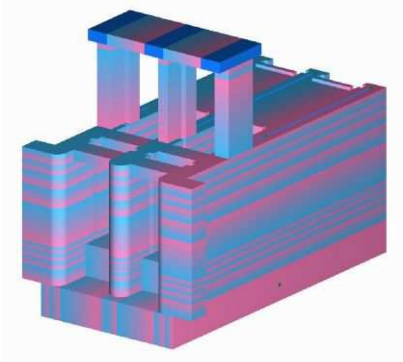
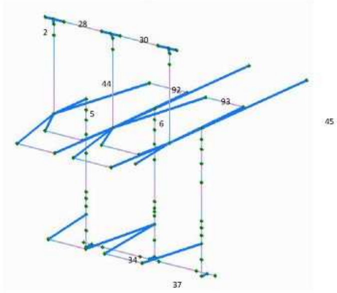
 Entire model image  Entire model frame	 Entire model image  Entire model frame
Bahr Yusef and Ibrahimia regulator	Badraman regulator (Diroutiah canal)
 Entire model image  Entire model frame	 Entire model image  Entire model frame
Abo Gabal regulator	Sahelyia regulator

Figure11-3.29 Structural model of regulators

Table11-3.6 Result of structural analysis of Bahr Yusef regulator

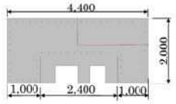
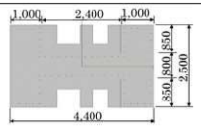
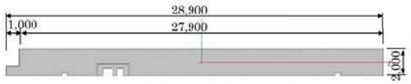
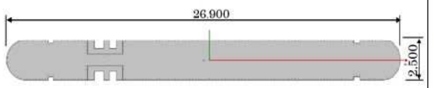
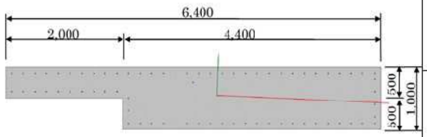
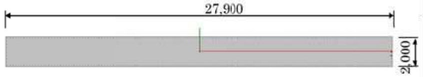
Name of target element	Outline of target element	Bar arrangement	Normal or Seismic	element №	Loading Case	Moment direction	Actual stress by structural analysis			σ'c(N/mm^2)	σs(N/mm^2)	σ's(N/mm^2)	τ(N/mm^2)	Judgement
							M(kN·m)	N(kN·m)	S(kN·m)	σca(N/mm^2)	σsa (N/mm^2)	σ'sa(N/mm^2)	τa(N/mm^2)	
Upper pier at abutment		D16@200	Normal	70	5	–	-2,587.5	2,008.1	-913.6	3.05	154.31	35.29	0.15	OK
										9.50	200	200	0.70	
			Seismic	70	10		-2,702.9	1,979.8	-913.4	3.18	168.71	36.34	0.15	OK
										10.92	230	230	0.81	
Upper pier at center	 1,000 2,400 1,000 350 800 850 2,500 4,400	D16@200	Normal	67	5	–	-1,657.8	2,723.7	564.7	1.43	10.85	20.23	0.07	OK
										9.50	200	200	0.70	
			Seismic	67	10		-1,583.1	2,748.0	695.8	1.53	12.75	21.60	0.08	OK
										10.92	230	200	0.81	
Pier at abutment		D16@200	Normal	132	5	–	-11,831.4	9,639.0	457.2	1.69	64.11	20.93	0.01	OK
										9.50	200	200	0.70	
			Seismic	132	10		-13,018.0	9,312.3	834.2	1.92	82.04	23.22	0.02	OK
										10.92	230	230	0.81	
Pier at center		D16@200	Normal	117	6	–	-22,612.0	19,025.8	1,072.1	0.58	0.00	8.41	0.02	OK
										9.50	200	200	0.70	
			Seismic	117	9		-24,164.3	18,330.7	2,880.9	1.17	11.78	16.56	0.05	OK
										10.92	230	230	0.81	
Gate operation stage		D16@200	Normal	9	13	Tension at upper side	-782.2	-551.9	-36.5	1.61	157.60	5.45	0.01	OK
										9.50	200	200	0.70	
			Seismic	9	12		-534.8	-600.4	-36.7	1.33	156.59	1.37	0.01	OK
										10.92	230	230	0.81	
		D16@200	Normal	3	13	Tension at lower side	-339.8	-167.1	405.2	0.69	48.35	6.38	0.07	OK
										9.50	200	200	0.70	
			Seismic	3	12		-196.2	-190.9	409.6	1.82	149.82	8.15	0.00	OK
										10.92	230	230	0.81	
Bottom foundation		D18@200	Normal	88	3	Tension at upper side	-14,179.1	908.2	6,619.0	2.12	199.15	19.69	0.13	OK
										9.50	200	200	0.70	
			Seismic	88	9		-8,473.1	5,677.6	3,590.9	1.16	56.15	13.60	0.07	OK
										10.92	230	230	0.81	
		D18@200	Normal	86	13	Tension at lower side	-2,335.2	1,327.7	4,532.6	0.33	18.15	3.74	0.09	OK
										9.50	200	200	0.70	
			Seismic	86	12		-2,677.3	1,431.5	4,491.1	0.38	21.88	4.28	0.09	OK
										10.92	230	230	0.81	

Table11-3.7 Result of structural analysis of Ibrahimia regulator

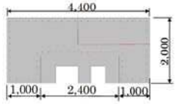
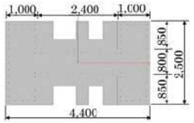
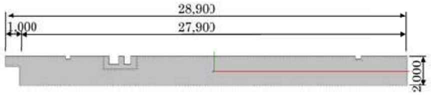
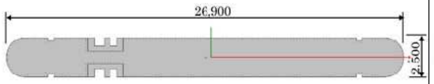
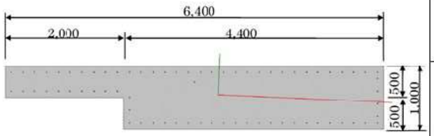
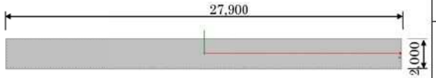
Name of target element	Outline of target element	Bar arrangement	Normal or Seismic	element №	Loading Case	Moment direction	Actual stress by structural analysis			σ'c(N/mm^2)	σs(N/mm^2)	σ's(N/mm^2)	τ(N/mm^2)	Judgement
							M(kN·m)	N(kN·m)	S(kN·m)	σ'ca(N/mm^2)	σsa (N/mm^2)	σ'sa(N/mm^2)	τa(N/mm^2)	
Upper pier at abutment		D16@200	Normal	66	5	–	2,946.1	2,073.6	1,131.4	3.53	193.54	40.06	0.18	OK
										9.50	200	200	0.70	
			Seismic	66	10		2,829.2	2,105.0	1,135.3	3.33	177.34	38.11	0.18	OK
										10.92	230	230	0.81	
Upper pier at center	 1,000 2,400 1,000 850 800 850 2,500 4,400	D16@200	Normal	67	5	–	-1,670.3	2,699.7	617.3	1.56	13.69	22.03	0.07	OK
										9.50	200	200	0.70	
			Seismic	67	10		1,702.8	2,725.3	743.8	1.66	15.68	23.35	0.09	OK
										10.92	230	230	0.81	
Pier at abutment		D16@200	Normal	136	5	–	-13,026.6	9,682.2	-741.5	1.78	69.21	21.93	0.01	OK
										9.50	200	200	0.70	
			Seismic	136	10		-13,964.6	9,292.8	-475.0	1.79	71.15	21.96	0.01	OK
										10.92	230	230	0.81	
Pier at center		D16@200	Normal	117	4	–	-23,082.2	18,995.4	594.2	0.57	0.00	8.39	0.01	OK
										9.50	200	200	0.70	
			Seismic	117	9		-24,515.8	18,235.3	2,886.8	1.18	12.26	16.68	0.05	OK
										10.92	230	230	0.81	
Gate operation stage		D18@200	Normal	6	13	Tension at upper side	-624.0	-475.5	31.9	1.42	141.30	4.09	0.01	OK
										9.50	200	200	0.70	
			Seismic	6	12		-444.2	-571.1	35.3	1.21	146.01	0.32	0.01	OK
										10.92	230	230	0.81	
		D18@200	Normal	12	13	Tension at lower side	-278.9	-137.3	-385.1	0.39	34.13	3.32	0.06	OK
										9.50	200	200	0.70	
			Seismic	12	12		-165.5	-182.9	-400.0	0.55	39.86	4.70	0.07	OK
										10.92	230	230	0.81	
Bottom foundation		D18@200	Normal	85	3	Tension at upper side	-13,535.0	581.0	11,014.1	2.02	193.71	18.47	0.21	OK
										9.50	200	200	0.70	
			Seismic	85	8		-13,235.1	583.0	10,690.8	2.00	189.58	18.42	0.20	OK
										10.92	230	230	0.81	
		D18@200	Normal	87	3	Tension at lower side	-1,882.4	441.4	14,338.7	0.28	22.32	3.36	0.27	OK
										9.50	200	200	0.70	
			Seismic	87	8		-1,907.4	467.6	13,941.8	0.29	22.47	2.98	0.27	OK
										10.92	230	230	0.81	

Table11-3.8 Result of structural analysis of Badraman regulator

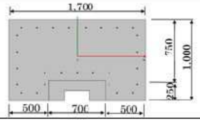
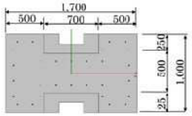
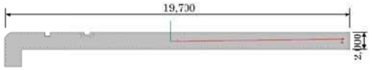
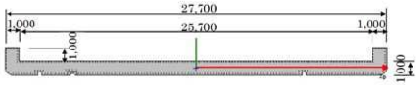
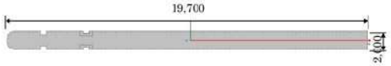
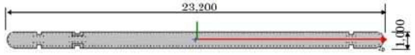
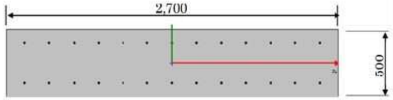
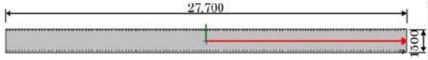
Name of target element	Outline of target element	Bar arrangement	Normal or Seismic	element №	Loading Case	Moment drecion	Actual stress by structural analysis M(kN·m)	N(kN·m)	S(kN·m)	σ'c(N/mm²) σca(N/mm²)	σs(N/mm²) σsa (N/mm²)	σ's(N/mm²) σ'sa(N/mm²)	τ(N/mm²) τa(N/mm²)	Judgement
Upper pier at abutment		D16@200	Normal	95	4	–	122.6	225.4	72.8	1.22	31.41	12.87	0.06	OK
										9.50	200	200	0.70	
			Seismic	95	11		116.7	226.4	62.0	1.16	28.19	12.42	0.05	OK
										10.92	230	230	0.81	
Upper pier at center		D16@200	Normal	11	4	–	36.9	127.7	-24.8	0.34	2.58	4.18	0.02	OK
										9.50	200	200	0.70	
			Seismic	11	11		51.5	120.9	-28.8	0.53	8.58	6.10	0.02	OK
										10.92	230	230	0.81	
Pier at abutment (1)		D16@200	Normal	4	1	–	-2,814.3	1,740.7	129.0	0.84	42.59	9.75	0.02	OK
										9.50	200	200	0.70	
			Seismic	4	8		-3,786.3	1,429.7	169.5	0.93	50.83	10.57	0.02	OK
										10.92	230	200	0.81	
Pier at abutment (2)		D16@200	Normal	135	6		-20,595.9	3,451.1	1,346.8	0.66	17.38	8.84	0.05	OK
										9.50	200	200	0.70	
			Seismic	135	9		-20,771.3	3,206.7	1,171.0	0.65	17.64	8.72	0.04	OK
										10.92	230	200	0.81	
Pier at center (1)		D16@200	Normal	3	1	–	3,873.5	1,508.6	263.6	1.45	62.46	12.98	0.02	OK
										9.50	200	200	0.70	
			Seismic	3	11		2,449.6	892.1	71.4	1.43	77.47	10.76	0.01	OK
										10.92	230	230	0.81	
Pier at center (2)		D16@200	Normal	101	6	–	5,291.8	2,395.9	226.7	0.31	1.27	4.19	0.01	OK
										9.50	200	200	0.70	
			Seismic	101	9		4,477.9	1,905.2	231.2	0.25	1.10	3.40	0.01	OK
										10.92	230	230	0.81	
Gate operation stage		D16@200	Normal	18	3	Tension at upper side	-35.5	-20.9	-48.9	0.79	34.10	1.84	0.05	OK
										9.50	200	200	0.70	
			Seismic	18	12		-39.0	-24.7	-49.0	0.83	35.70	2.00	0.05	OK
										10.92	200	200	0.81	
		D16@200	Normal	15	3	Tension at lower side	-33.9	3.8	-32.9	0.22	8.50	2.19	0.03	OK
										9.50	200	200	0.70	
			Seismic	15	12		-37.3	1.8	-35.1	0.27	10.36	2.63	0.03	OK
										10.92	200	230	0.81	
Bottom foundation		D16@200	Normal	80	13	Tension at upper side	-905.2	357.6	-1,100.3	0.27	18.70	2.43	0.03	OK
										9.50	200	200	0.70	
			Seismic	80	12		-937.0	358.1	-988.2	0.28	19.56	2.50	0.02	OK
										10.92	230	200	0.81	
		D16@200	Normal	74	13	Tension at lower side	-1,107.4	348.2	1,008.2	0.33	24.43	2.88	0.03	OK
										9.50	200	200	0.70	
			Seismic	74	8		-1,144.2	349.5	797.6	0.33	24.40	2.88	0.03	OK
										10.92	230	200	0.81	

Table11-3.9 Result of structural analysis of Abo Gabal regulator

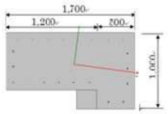
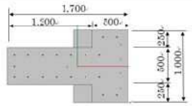
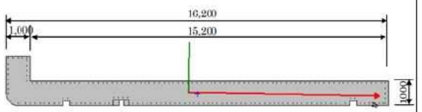
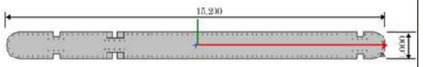
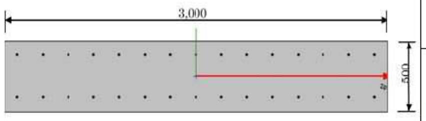
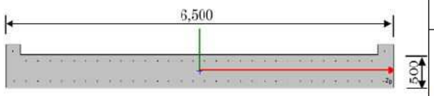
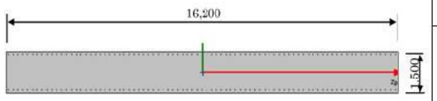
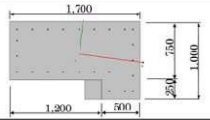
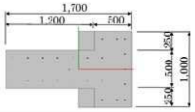
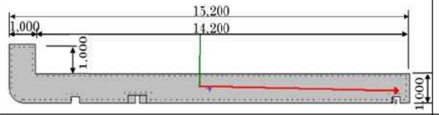
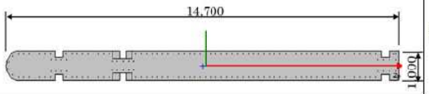
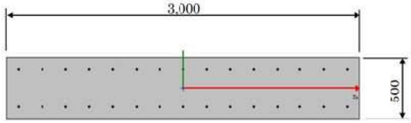
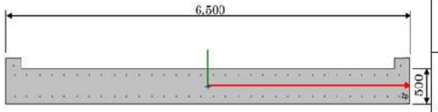
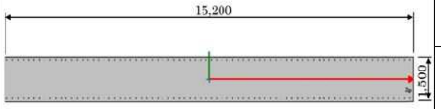
Name of target element	Outline of target element	Bar arrangement	Normal or Seismic	element №	Loading Case	Moment directon	Actual stress by structural analysis			σ'c(N/mm^2)	σs(N/mm^2)	σ's(N/mm^2)	τ(N/mm^2)	Judgement
							M(kN･m)	N(kN･m)	S(kN･m)	σca(N/mm^2)	σsa (N/mm^2)	σ'sa(N/mm^2)	τa(N/mm^2)	
Upper pier at abutment		D16@200	Normal	73	5	–	43.0	210.5	28.2	0.39 9.50	2.51 200	4.88 200	0.02 0.70	OK
			Seismic	73	11		-12.0	210.0	6.5	0.20 10.92	0.00 230	2.79 230	0.00 0.81	OK
Upper pier at center		D16@200	Normal	3	13	–	29.8	128.1	-14.4	0.47 9.50	5.89 200	5.36 200	0.01 0.70	OK
			Seismic	3	8		31.2	165.6	-14.5	0.47 10.92	4.14 230	5.60 230	0.01 0.81	OK
Pier at abutment		D16@200	Normal	11	6		-3,108.3	2,381.6	794.8	0.87 9.50	26.08 200	11.06 200	0.04 0.70	OK
			Seismic	11	8		-2,921.8	2,402.6	308.1	0.67 10.92	14.66 230	8.82 230	0.03 0.81	OK
Pier at center		D16@200	Normal	10	6	–	-381.2	627.0	210.8	0.41 9.50	11.93 200	4.24 200	0.02 0.70	OK
			Seismic	10	8		-332.5	735.2	128.8	0.31 10.92	6.00 230	3.51 230	0.01 0.81	OK
Gate operation stage		D16@200	Normal	36	3	Tension at upper side	-29.6	0.8	-60.4	0.63 9.50	27.68 200	0.50 200	0.05 0.70	OK
			Seismic	36	8		-28.7	3.5	-59.1	0.64 10.92	26.80 230	1.07 230	0.05 0.81	OK
		D16@200	Normal	40	4	Tension at lower side	-11.9	-5.1	-12.2	0.11 9.50	4.52 200	0.81 200	0.01 0.70	OK
			Seismic	40	8		-12.6	-11.8	-15.1	0.04 10.92	5.27 230	0.42 230	0.01 0.81	OK
Management bridge		D16@200	Normal	161	4	Tension at uppor side	-239.8	-30.3	338.1	2.22 9.50	144.56 200	2.21 200	0.13 0.70	OK
			Seismic	161	8		-235.9	-98.3	344.0	2.28 10.92	156.14 230	7.74 230	0.13 0.81	OK
		D16@200	Normal	158	3	Tension at lower side	-87.3	-91.1	-82.3	0.61 9.50	18.08 200	4.96 200	0.03 0.70	OK
			Seismic	158	8		-81.1	-88.5	-61.7	0.81 10.92	21.36 230	6.58 230	0.06 0.81	OK
Bottom foundation		D16@200	Normal	65	3	Tension at upper side	1,026.4	301.6	-648.9	0.45 9.50	28.15 200	4.37 200	0.04 0.70	OK
			Seismic	65	8		1,021.3	295.7	-623.6	0.45 10.92	28.95 230	4.41 230	0.03 0.81	OK
		D16@200	Normal	62	3	Tension at lower side	1,768.6	575.2	-250.7	0.47 9.50	21.54 200	5.23 200	0.01 0.70	OK
			Seismic	59	8		1,633.9	568.0	43.6	0.44 10.92	20.01 230	4.93 230	0.00 0.81	OK

Table11-3.10 Result of structural analysis of Sahelyia regulator

Name of target element	Outline of target element	Bar arrangement	Normal or Seismic	element №	Loading Case	Moment direction	Actual stress by structural analysis			σ'c(N/mm^2)	σs(N/mm^2)	σ's(N/mm^2)	τ(N/mm^2)	Judgement
							M(kN·m)	N(kN·m)	S(kN·m)	σca(N/mm^2)	σsa (N/mm^2)	σ'sa(N/mm^2)	τa(N/mm^2)	
Upper pier at abutment		D16@200	Normal	2	6	–	-38.4	102.5	5.8	0.45	7.01	5.12	0.01	OK
										9.50	200	200	0.70	
			Seismic	2	9		-24.7	95.8	7.1	0.25	1.68	3.04	0.01	OK
										10.92	230	230	0.81	
Upper pier at center		D16@200	Normal	44	6	–	42.7	289.0	27.7	0.63	1.67	8.24	0.02	OK
										9.50	200	200	0.70	
			Seismic	44	9		10.8	287.2	3.2	0.33	0.00	4.70	0.00	OK
										10.92	230	230	0.81	
Pier at abutment		D16@200	Normal	5	6	–	672.5	588.9	-297.7	0.41	32.50	4.15	0.03	OK
										9.50	200	200	0.70	
			Seismic	5	9		729.8	571.5	390.7	0.39	31.01	3.89	0.02	OK
										10.92	230	230	0.81	
Pier at center		D16@200	Normal	6	6	–	-674.4	480.1	730.7	0.23	4.09	2.74	0.06	OK
										9.50	200	200	0.70	
			Seismic	6	11		-1,024.5	365.4	766.1	0.13	1.50	1.75	0.07	OK
										10.92	230	230	0.81	
Gate operation stage		D16@200	Normal	30	5	Tension at upper side	-20.5	14.4	49.7	0.42	16.59	0.80	0.04	OK
										9.50	200	200	0.70	
			Seismic	30	8		-15.4	12.1	42.4	0.32	12.36	0.77	0.04	OK
										10.92	230	230	0.81	
		D16@200	Normal	28	3	Tension at lower side	-17.6	9.1	-46.2	0.33	14.41	0.17	0.04	OK
										9.50	200	200	0.70	
			Seismic	28	11		-12.9	5.8	-43.9	0.26	10.98	0.36	0.04	OK
										10.92	230	230	0.81	
Management bridge		D16@200	Normal	93	5	Tension at upper side	-210.9	-53.1	321.0	1.78	125.76	0.00	0.12	OK
										9.50	200	200	0.70	
			Seismic	93	8		-160.5	-37.5	264.7	1.36	95.96	5.98	0.14	OK
										10.92	230	230	0.81	
		D16@200	Normal	92	6	Tension at lower side	329.6	371.9	324.1	2.27	106.24	9.96	0.12	OK
										9.50	200	200	0.70	
			Seismic	92	11		333.8	312.2	-320.5	2.21	112.91	7.69	0.12	OK
										10.92	230	230	0.81	
Bottom foundation		D16@200	Normal	37	5	Tension at upper side	2,191.7	130.9	-857.7	0.51	28.04	5.60	0.05	OK
										9.50	200	200	0.70	
			Seismic	37	12		1,442.1	282.6	-721.3	0.31	13.79	3.62	0.03	OK
										10.92	230	230	0.81	
		D16@200	Normal	34	5	Tension at lower side	830.5	192.8	-714.7	0.39	25.71	3.77	0.04	OK
										9.50	200	200	0.70	
			Seismic	37	8		1,884.5	386.3	-1,005.9	0.38	15.29	4.44	0.05	OK
										10.92	230	230	0.81	

12. Foundation Works for Regulator

12-1 Determining the foundation type

12-1-1 Concept and flow

Chapter 11,'Stability and Structural Calculation', shows the results of the examination of foundation works. The ground reaction force (actual stress of foundation) Figures calculated for each case are available. Each layer's bearing capacity was also assessed. The examination was conducted according to the flow chart in Figure 12-1.2. The common foundation type is shown in Figure 12-1.1.

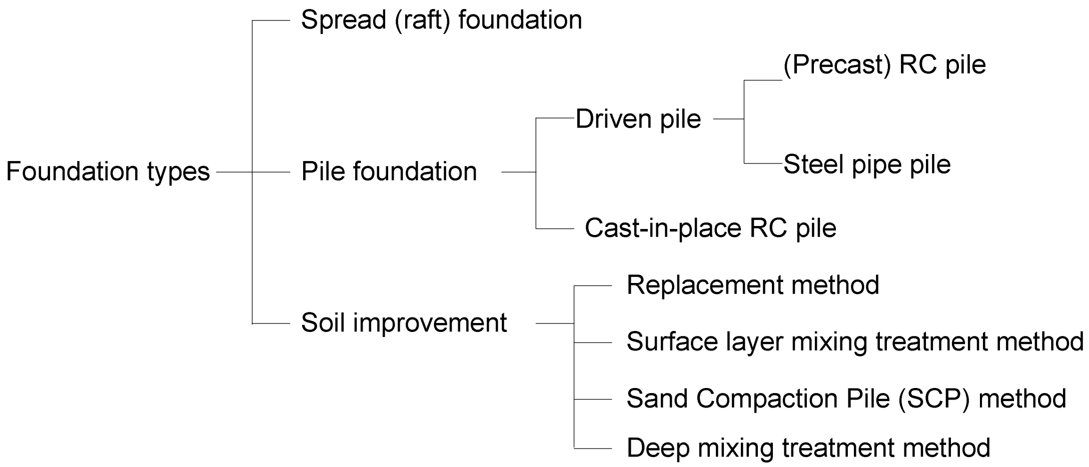


Figure12-1.1 Classification of foundation works

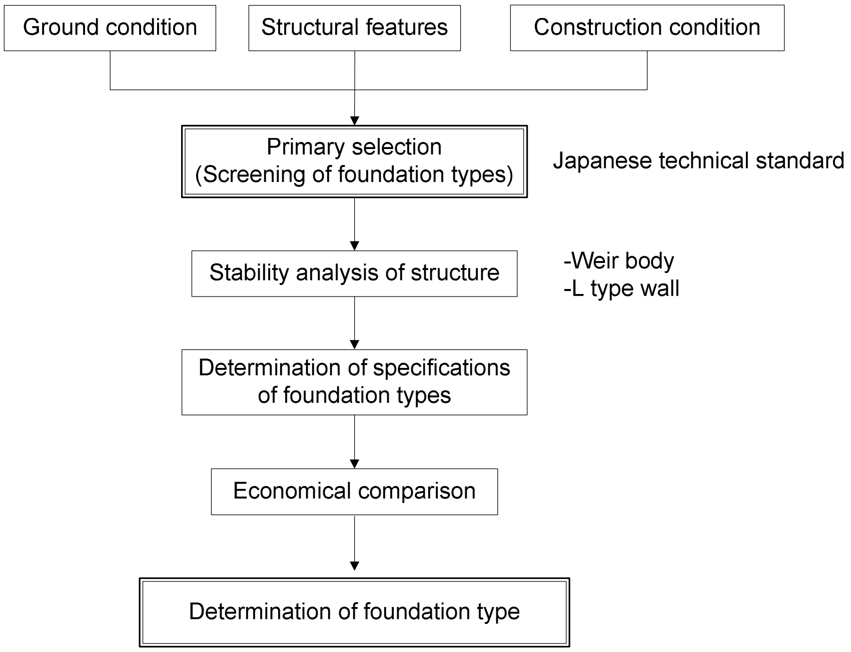

Ground condition
Structural features
Construction condition
Primary selection
(Screening of foundation types)
Japanese technical standard
Stability analysis of structure
-Weir body
-L type wall
Determination of specifications
of foundation types
Economical comparison
Determination of foundation type

Figure12-1.2 Flowchart of foundation works

As for the bearing capacity of Terzaghi, the Egyptian code equation has a different applied co-efficient that gives a larger result than that of the Japanese equation. Under sand conditions, the results of the bearing capacity from the Egyptian code are almost seven times greater than the Japanese Figures. There is also a substantial difference in the general evaluation as a result of the difference in N value (refer to Appendix).

To overcome these great differences in results, the Egyptian consultant usually applies a settlement method in combination with the Terzaghi method stipulated in Egyptian code. The Bahr Yusef and Ibrahimia regulators bearing capacity results arrived at by the settlement method are almost the as those arrived at by the Japanese equation.

Accordingly, the bearing capacity should be evaluated by a combination of the Terzaghi formula in the Egyptian code and the settlement method, the latter being applied under sand layer conditions. This decision was approved by the expert panel meeting at the 19th TAC meeting.

12-1-2 Primary selection of foundation method

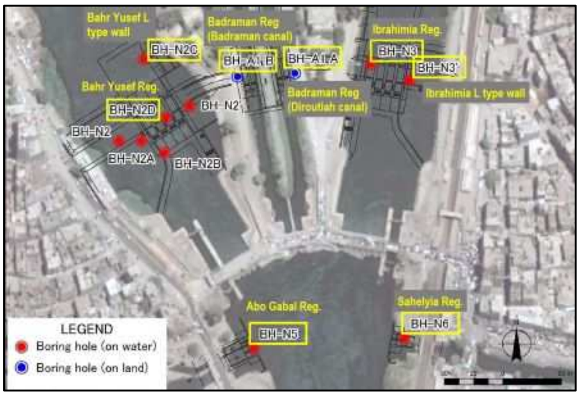


Figure12-1.3 Locations of borehole for design

The bearing capacity of every regulator must be assessed using the ratio in Table 12-1.1.

(1) Bearing capacity

The equation for calculating bearing capacity should be consideration with eccentricity of acted load, which is in the basis of the modified Terzaghi method. The ultimate bearing capacity must take a safety ratio into account. Calculating bearing capacity takes the following into consideration:

a) Allowable bearing capacity of foundation should be secured the following safety ratio against the ultimate bearing capacity considering the eccentricity of the load.

Table12-1.1 Safety ratio for bearing capacity (Egyptian code)

Normal	Seismic
2.5	1.8

b) Ultimate bearing capacity of the foundation using revised Terzaghi formula considering eccentricity of the load in the Egyptian code, is calculated as the followings:

$$qu = c \cdot Nc \cdot \lambda c \cdot ic + \gamma 1 \cdot Df \cdot Nq \cdot \lambda q \cdot iq + \gamma 2 \cdot Be \cdot Nr \cdot \lambda r \cdot ir$$

$$qa = 1/n \cdot qu$$

Where,

qu ; ultimate bearing capacity considering eccentricity of the load (kN/m^2)
qa ; allowable bearing capacity (kN/m^2)
n ; safety ratio (Table 12-1.2)
Nc ; (Nq-1) / tanφ
Nq ; $e^{\pi \cdot \tan\phi} \cdot \tan^2(45+\phi/2)$
Nr ; (Nq-1)tanφ
ic ; iq-(1-iq)/(Nq-1)
iq ; $\{1-0.7 \cdot (H*Fb/(V*Fb+A \cdot c \cdot \cot\phi))\}^3$
ir ; $\{1-(Hb/(Vb+A \cdot c \cdot \cot\phi))\}^3$
$\gamma 1$, $\gamma 2$; unit weight of ground below foundation load surface (kN/m^3)
*when foundation level is under groundwater level, apply submerged unit weight
λc, λr, λq ; refer to Table 12-1.2

Table12-1.2 Shape factor of the foundation (Egyptian code)

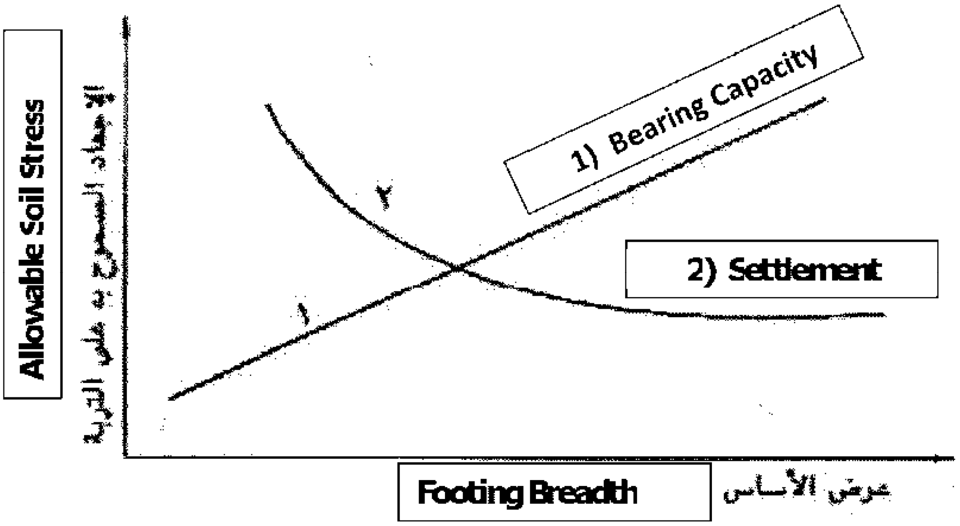
Shape of foundation	Belt type	Square or Circle	Rectangle, ellipse, or oval
λq, λc	1.0	1.3	1+0.3･(Be/Le)
λr	1.0	0.7	1-0.3･(Be/Le)

Be ; width of foundation for the effective loading considering eccentricity (m)
Be＝B－2e

c) Allowable bearing capacity of foundation by the settlement method under the Egyptian code, explained as follows.

1. DESIGN REQUIREMENTS IN THE EGYPTIAN CODE OF SOIL MECHANICS AND FOUNDATION

- The design of shallow foundation according to the Egyptian code for soil mechanics requires the determination of allowable bearing capacity and the settlement of soil separately and takes the safe soil stress from the two conditions.
- Often, in large dimension foundation, the settlement is the governing condition in the design.
- The following Figure shows the relation between the allowable stress of soil and breadth of footing for the bearing capacity and the settlement (Figure 3.3 in the Egyptian code).



شكل (٣-٣) العلاقة بين الإجهاد المسموح به وعرض الأساس

١) لمعامل أمان معين من فشل تربة الأساس

٢) لمقدار معين من الهبوط

Relation between Allowable Stress & Footing Breadth

2. ALLOWABLE TOTAL SETTLEMNT

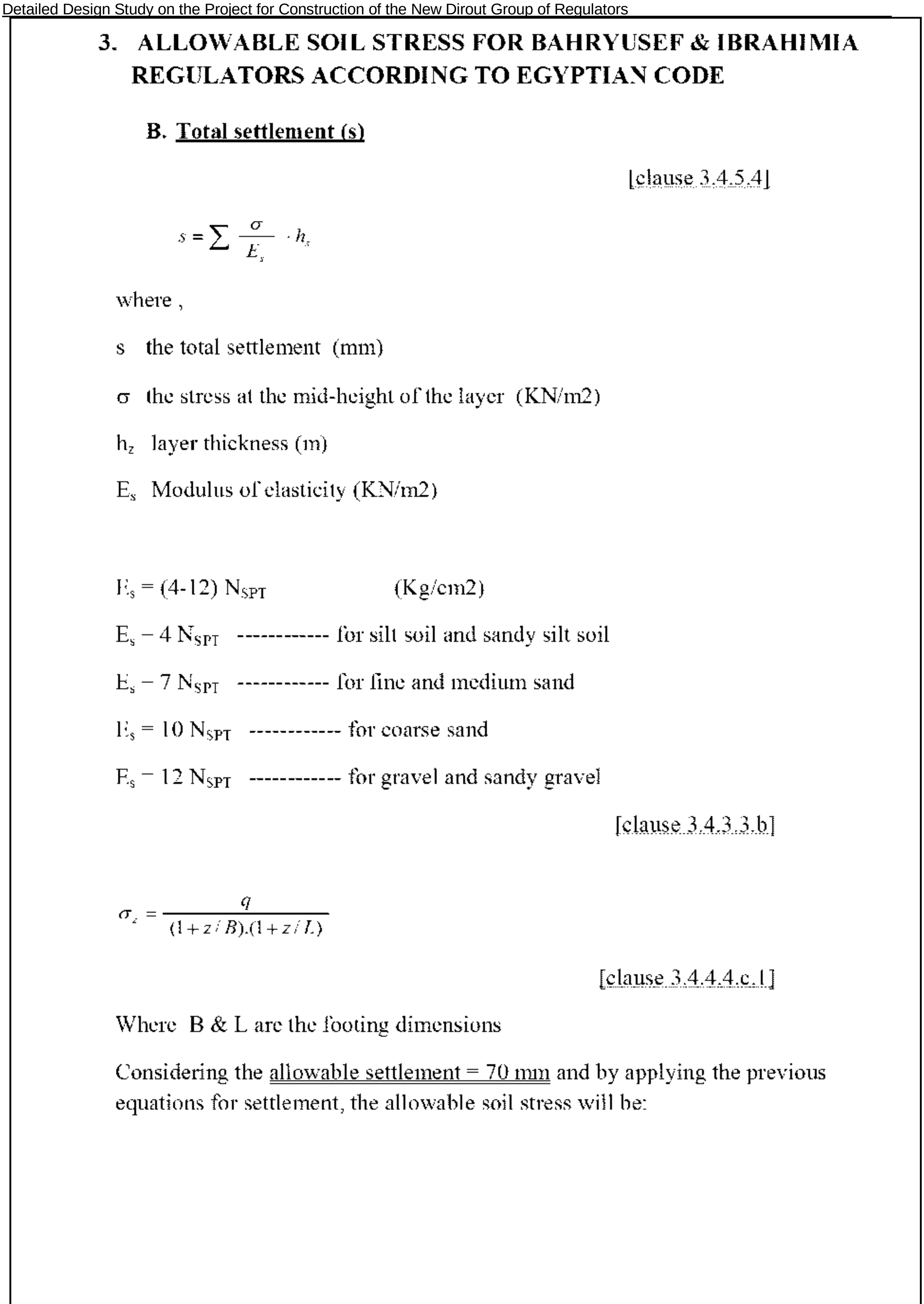
Total settlement $\leq$ 100 150 mm (Clay Soil)

Total settlement $\leq$ 70 – 100 mm (Sandy Soil)

[The greatest values used for more stiff structures]

[clause 3.2.6.6.a]

Figure12-1.4 Concept of settlement by Egyptian code (1/2)



3. ALLOWABLE SOIL STRESS FOR BAHRYUSEF & IBRAHIMIA REGULATORS ACCORDING TO EGYPTIAN CODE

B. Total settlement (s)

[clause 3.4.5.4]

$$s = \sum \frac{\sigma}{E_s} \cdot h_z$$

where ,

s the total settlement (mm)

σ the stress at the mid-height of the layer (KN/m2)

h_z layer thickness (m)

E_s Modulus of elasticity (KN/m2)

$E_s = (4\text{-}12)\ N_{SPT}$ (Kg/cm2)

$E_s = 4\ N_{SPT}$ ------------ for silt soil and sandy silt soil

$E_s = 7\ N_{SPT}$ ------------ for fine and medium sand

$E_s = 10\ N_{SPT}$ ------------ for coarse sand

$E_s = 12\ N_{SPT}$ ------------ for gravel and sandy gravel

[clause 3.4.3.3.b]

$$\sigma_z = \frac{q}{(1+z/B).(1+z/L)}$$

[clause 3.4.4.4.c.1]

Where B & L are the footing dimensions

Considering the allowable settlement = 70 mm and by applying the previous equations for settlement, the allowable soil stress will be:

Figure12-1.5 Concept of settlement by Egyptian code (2/2)

d) Result of the calculations

From the calculations, the bearing capacity of each regulator is shown in Table 12-1.3.

Table12-1.3 Summary of bearing capacity

Regulator name and related structure		By Revised Terzaghi formula		By Settlement method (normal) (kN/m^2)	Remarks
		Normal (kN/m^2)	Seismic (kN/m^2)		
Bahr Yusef regulator	Regulator foundation (Br.No.BH-N2D)	267.2(Dir. F.A) 269.2(Dir. W.A)	300.0(Dir. F.A) 306.2(Dir. W.A)	**49.16** (applied)	Sand ground: N=6, φ=23°
	L type wall (H-N2C)	**19.3**(Dir. F.A) -(Dir. W.A) (applied)	**24.6**(Dir. F.A) -(Dir. W.A)	36.37	Sand ground: N=8, φ25°
Ibrahimia regulator	Regulator foundation (Br.No.BH-N3')	511.5(Dir. F.A) 512.8(Dir. W.A)	573.1(Dir. F.A) 585.5(Dir. W.A)	**91.48** (applied)	Sand ground: N=13, φ27°
	L type wall (Br.No.BH-N3)	**19.3**(Dir. F.A) - (Dir. W.A) (applied)	**24.6**(Dir. F.A) -(Dir. W.A)	80.69	Sand ground: N=9, φ25°
Badraman regulator	Badraman canal (Br.No.BH-A1 B)	**239.24**(Dir. F.A) **487.07**(Dir. W.A) (applied)	**317.39**(Dir. F.A) **652.91**(Dir. W.A)	— (Clay layer)	Silty clay: N=18, φ0°
	Diroutiah canal (Br.No.BH-A1 A)	**191.36**(Dir. F.A) **309.68**(Dir. W.A) (applied)	**251.30**(Dir. F.A) **417.04**(Dir. W.A)	— (Clay layer)	Silty clay: N=14, φ0°
Abo Gabal regulator	Both of Abo Gabal and Irad Delgaw canal (Br.No.BH-N5)	**383.69**(Dir. F.A) **415.24**(Dir. W.A) (applied)	**513.37**(Dir. F.A) **570.44**(Dir. W.A)	— (Clay layer)	Silty clay: N=25, φ0°
Sahelyia regulator (Br.No.BH-N6)		**223.25**(Dir. F.A) **317.02**(Dir. W.A) (applied)	**286.60**(Dir. F.A) **418.43**(Dir. W.A)	— (Clay layer)	Silty clay: N=16, φ0°

Note1:Safety measures from landslides and eccentricity are by far more over than targeted range which is available to evaluate the numerical equation. Therefore, the direct foundation cannot apply to L type wall.

Note2:"Dir. F. A." shows "Direction of Flow Axis", "Dir. W.A." shows "Direction of Wire Axis"

(2) Evaluation of bearing capacity

When compared with the ground reaction force (that is the result of examining the stability of the regulators in chapter 11 “Stability and Structural Calculation" and the calculated bearing capacity on Table 12-1.4 for each case), it seems that the large scale regulators of Bahr Yusef and Ibrahimia do not have adequate bearing capacity. Therefore, direct foundation cannot be used with the Bahr Yusef and Ibrahimia regulators.

Accordingly, the ground reaction force (actual stress of foundation) found by examining the stability of the Bahr Yusef and Ibrahimia regulators is around 136kN/m^2.In order to ensure a bearing capacity against 136kN/m^2 (by backward calculation method), the necessary bearing capacity should be N=18 calculated at141kN/m^{2}N=18 layers are observed as follows.

・Bahr Yusef : 10m below (EL27.5m) from the bottom of designed apron (EL37.5m)

・Ibrahimia : 4m below (EL33.5m) from the bottom of designed apron (EL37.5m)

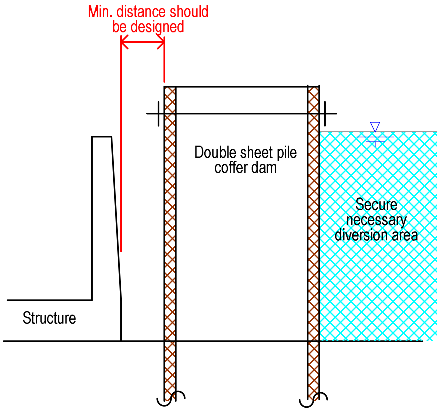

Min. distance should be designed
Double sheet pile coffer dam
Secure necessary diversion area
Structure

Figure12-1.6 Relation between double sheet pile and structure

The L type protection walls shortly downstream of Bahr Yusef and Ibrahimia regulator cannot use the direct foundation. These walls types are not designed with the footing slab behind the wall because of the marginal limitation of double sheet pile cofferdam (Figure 12-1.6). Therefore, the footing slab must be designed at the front of the wall, which means the resisted vertical force is by far smaller than the horizontal force due to earth and water pressure, so it overloads the landslide, eccentricity capacity, and bearing capacity. Accordingly, **L-type protection walls cannot use direct foundation.**

The small scale Badraman, Abo Gabal, and Sahelyia regulators have a clay layer around the bottom of the apron with a high N value, and sufficient bearing capacity. Hence **direct foundation should be applied to the small scale regulators.**

A comparison between the ground reaction force (actual stress of foundation) and the allowable bearing capacity is shown on Table 12-1.4.

Table12-1.4 Result of the examination of bearing capacity

Normal condition

		Geological conditions	Max. actual stress by stability exam. (kN/m2)	Min. bearing capacity (kN/m2)		Judgment (OK or NG)	N value	Remarks
Bahr Yusef	Regulator	sand	144.84	>	49.16	NG	6	
	L type wall	sand	68.53	>	19.3	NG	8	
Ibrahimia	Regulator	sand	144.82	>	91.48	NG	13	
	L type wall	sand	68.52	>	19.3	NG	9	
Badraman	Badraman regulator	clay	107.27	≦	239.24	**OK**	18	Raft foundation
	Diroutiah. regulator	clay	101.56	≦	191.36	**OK**	14	Raft foundation
Abo Gabal	Regulator	clay	106.47	≦	383.69	**OK**	25	Raft foundation
Sahelyia	Regulator	clay	141.89	≦	223.25	**OK**	16	Raft foundation

Seismic condition

		Geological conditions	Max. actual stress by stability exam. (kN/m2)	Min. bearing capacity (kN/m2)		Judgment (OK or NG)	N value	Remarks
Bahr Yusef	Regulator	sand	133.15	>	68.28$^{\text{note)}}$	NG	6	
	L type wall	sand	82.84	>	24.6	NG	8	
Ibrahimia	Regulator	sand	144.82	>	127.06$^{\text{note)}}$	NG	13	
	L type wall	sand	82.84	>	24.6	NG	9	
Badraman	Badraman regulator	clay	107.14	≦	317.39	**OK**	18	Raft foundation
	Diroutiah regulator	clay	95.86	≦	251.30	**OK**	14	Raft foundation
Abo Gabal	Regulator	clay	111.44	≦	513.37	**OK**	25	Raft foundation
Sahelyia	Regulator	clay	153.67	≦	286.60	**OK**	16	Raft foundation

Note: Seismic bearing capacity is assumed by normal bearing capacity to be as follows:

$68.28 kN/m^2 = 49.16\ kN/m^2 \times 2.5/1.8$, $127.06 kN/m^2 = 91.48\ kN/m^2 \times 2.5/1.8$

Bahr Yusef Regulator

The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt	**Borehole Logging Record** **Bore: BH-N2D**	Drilling Hole Dimension	Sanyu Consultants Inc.

DRILLING DETAILS	**Drilling Date:** 1/8/2015	**Drilled Depth:** 28.95 (mBGL)
Drilling Company: Misr Raymond F.	**Coordinates:** 283795 : 3050360	**Bore Diameter:** 101.6 (mm)
Drilling Method: Rotary Drilling	**Ground Elevation:** 39.3 (mAMSL)	**TOC Elevation:**M. Essam (mAGL)

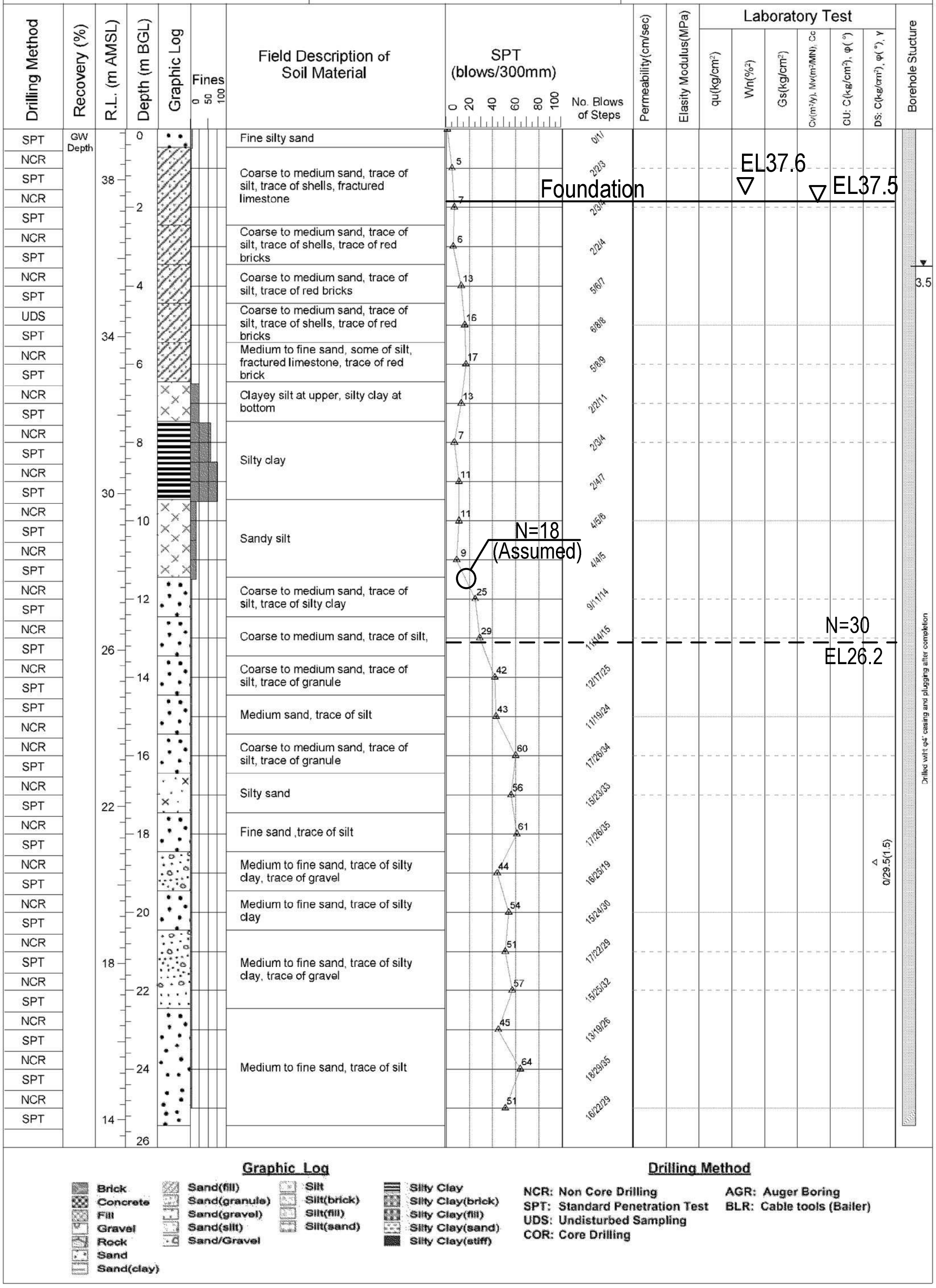
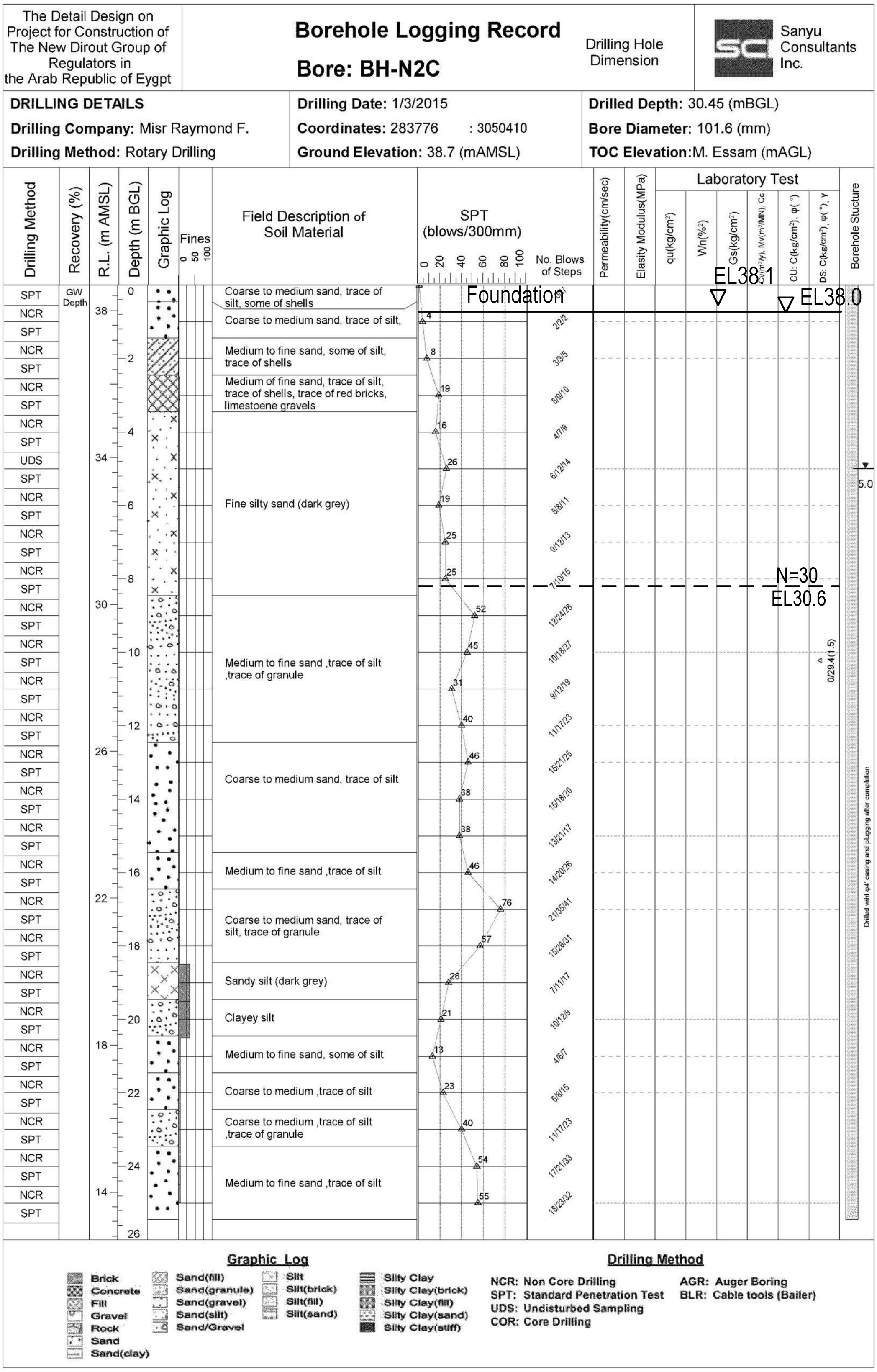


Figure12-1.7 Br No. BH-2D Bahr Yusef regulator

Bahr Yusef L type wall



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Egypt

Borehole Logging Record

Bore: BH-N2C

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS
Drilling Company: Misr Raymond F.
Drilling Method: Rotary Drilling

Drilling Date: 1/3/2015
Coordinates: 283776 : 3050410
Ground Elevation: 38.7 (mAMSL)

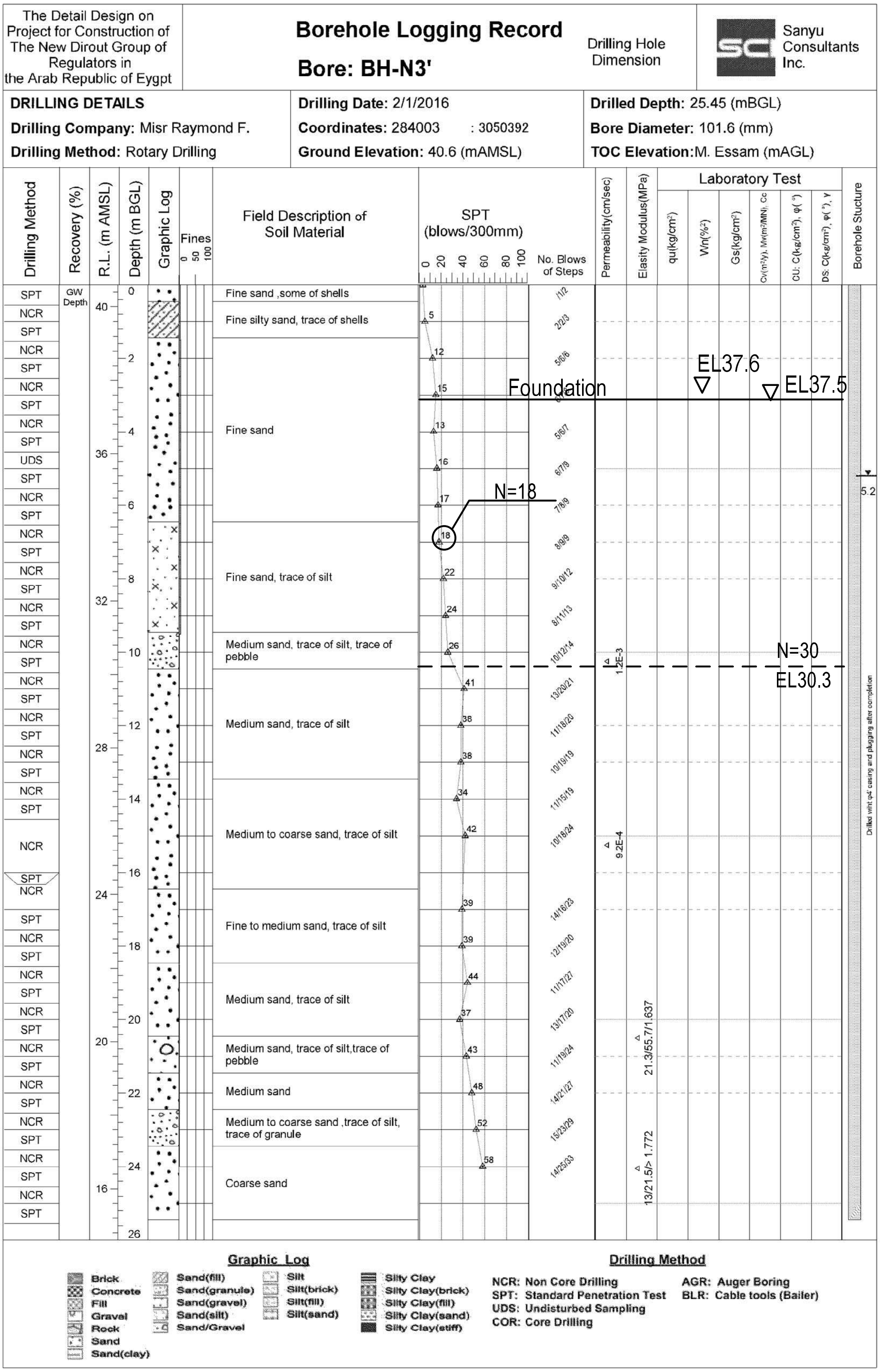
Drilled Depth: 30.45 (mBGL)
Bore Diameter: 101.6 (mm)
TOC Elevation:M. Essam (mAGL)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure12-1.8 Br No. BH-N2C Bahr Yusef regulator (L type wall)

Ibrahimia Regulator



The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N3'

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/1/2016

Coordinates: 284003 : 3050392

Ground Elevation: 40.6 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Field Description of Soil Material

Fine sand ,some of shells

Fine silty sand, trace of shells

Fine sand

Fine sand, trace of silt

Medium sand, trace of silt, trace of pebble

Medium sand, trace of silt

Medium to coarse sand, trace of silt

Fine to medium sand, trace of silt

Medium sand, trace of silt

Medium sand, trace of silt,trace of pebble

Medium sand

Medium to coarse sand ,trace of silt, trace of granule

Coarse sand

Graphic Log

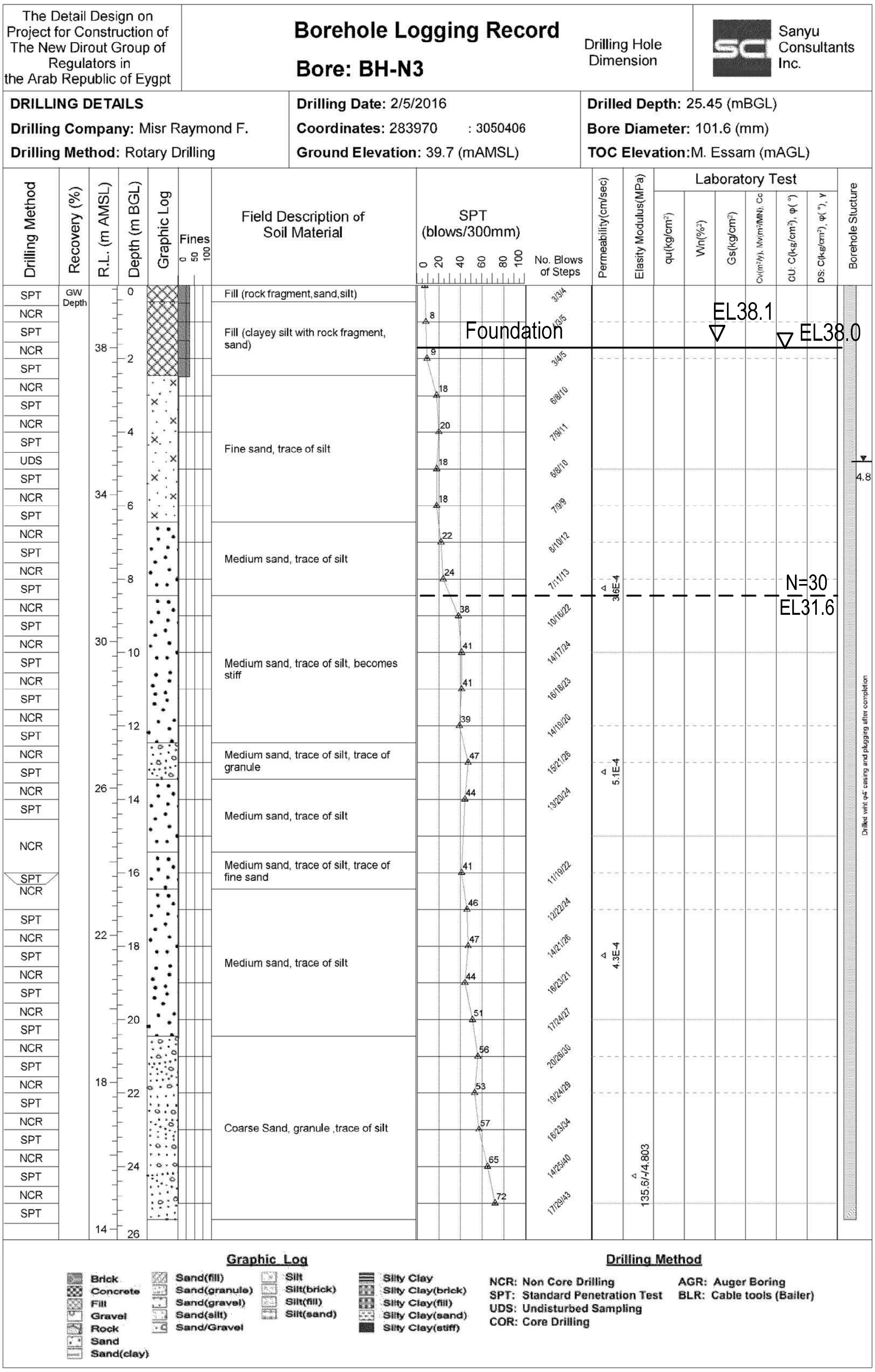
▨ Brick
▨ Concrete
▨ Fill
▨ Gravel
▨ Rock
▨ Sand
▨ Sand(clay)
▨ Sand(fill)
▨ Sand(granule)
▨ Sand(gravel)
▨ Sand(silt)
▨ Sand/Gravel
▨ Silt
▨ Silt(brick)
▨ Silt(fill)
▨ Silt(sand)
▨ Silty Clay
▨ Silty Clay(brick)
▨ Silty Clay(fill)
▨ Silty Clay(sand)
▨ Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure12-1.9 Br No. BH-N3' Ibrahimia regulator

Ibrahimia L type wall



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N3

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/5/2016

Coordinates: 283969 : 3050406

Ground Elevation: 39.7 (mAMSL)

Drilled Depth: 25.45 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Graphic Log

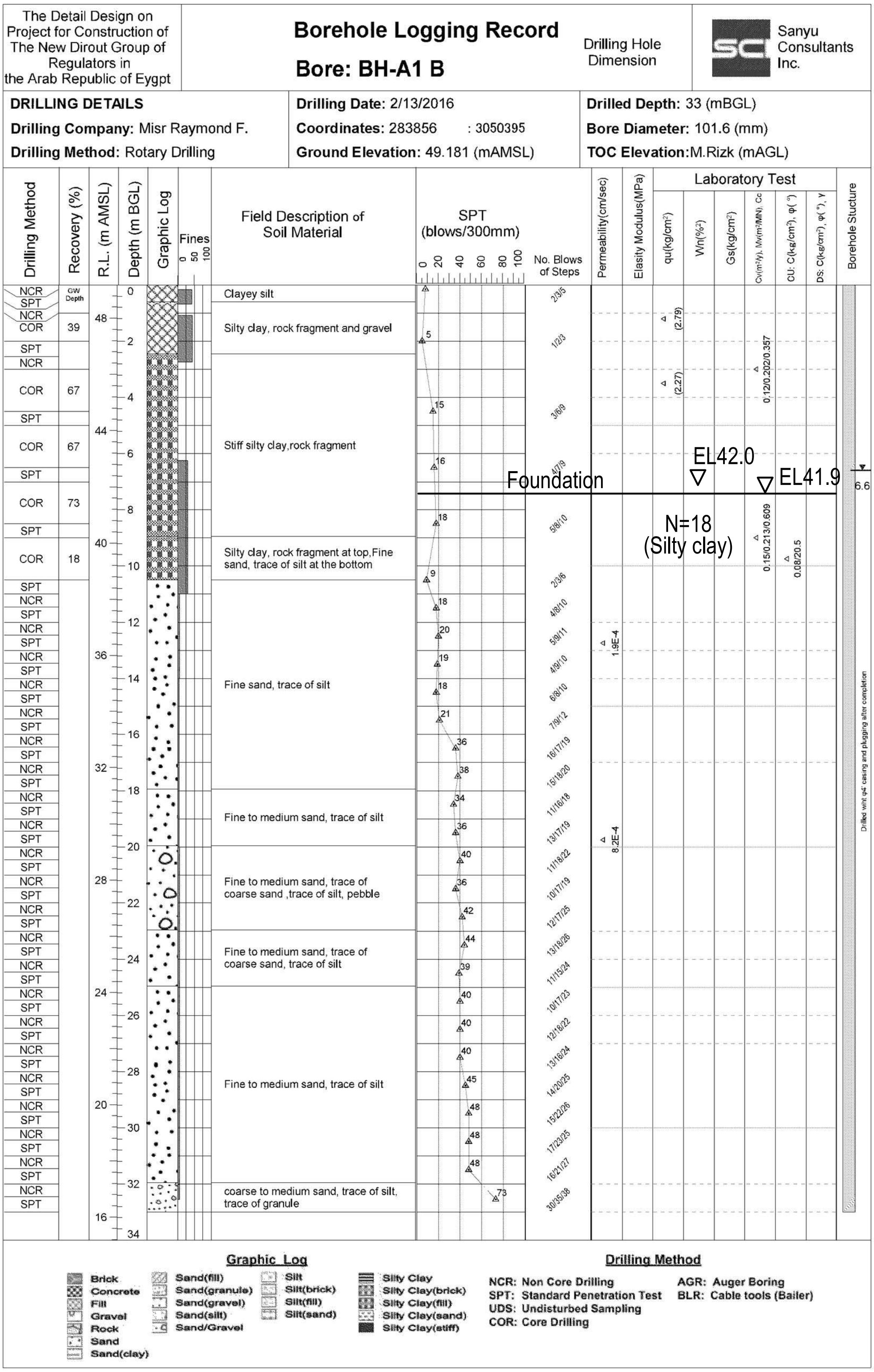
- ▨ Brick
- ▨ Concrete
- ▨ Fill
- ▨ Gravel
- ▨ Rock
- ▨ Sand
- ▨ Sand(clay)
- ▨ Sand(fill)
- ▨ Sand(granule)
- ▨ Sand(gravel)
- ▨ Sand(silt)
- ▨ Sand/Gravel
- ▨ Silt
- ▨ Silt(brick)
- ▨ Silt(fill)
- ▨ Silt(sand)
- ▨ Silty Clay
- ▨ Silty Clay(brick)
- ▨ Silty Clay(fill)
- ▨ Silty Clay(sand)
- ▨ Silty Clay(stiff)

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure12-1.10 Br No. BH-N3 Ibrahimia regulator (L type wall)

Badraman Regulator (Badraman canal)



The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-A1 B

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/13/2016

Coordinates: 283856 : 3050395

Ground Elevation: 49.181 (mAMSL)

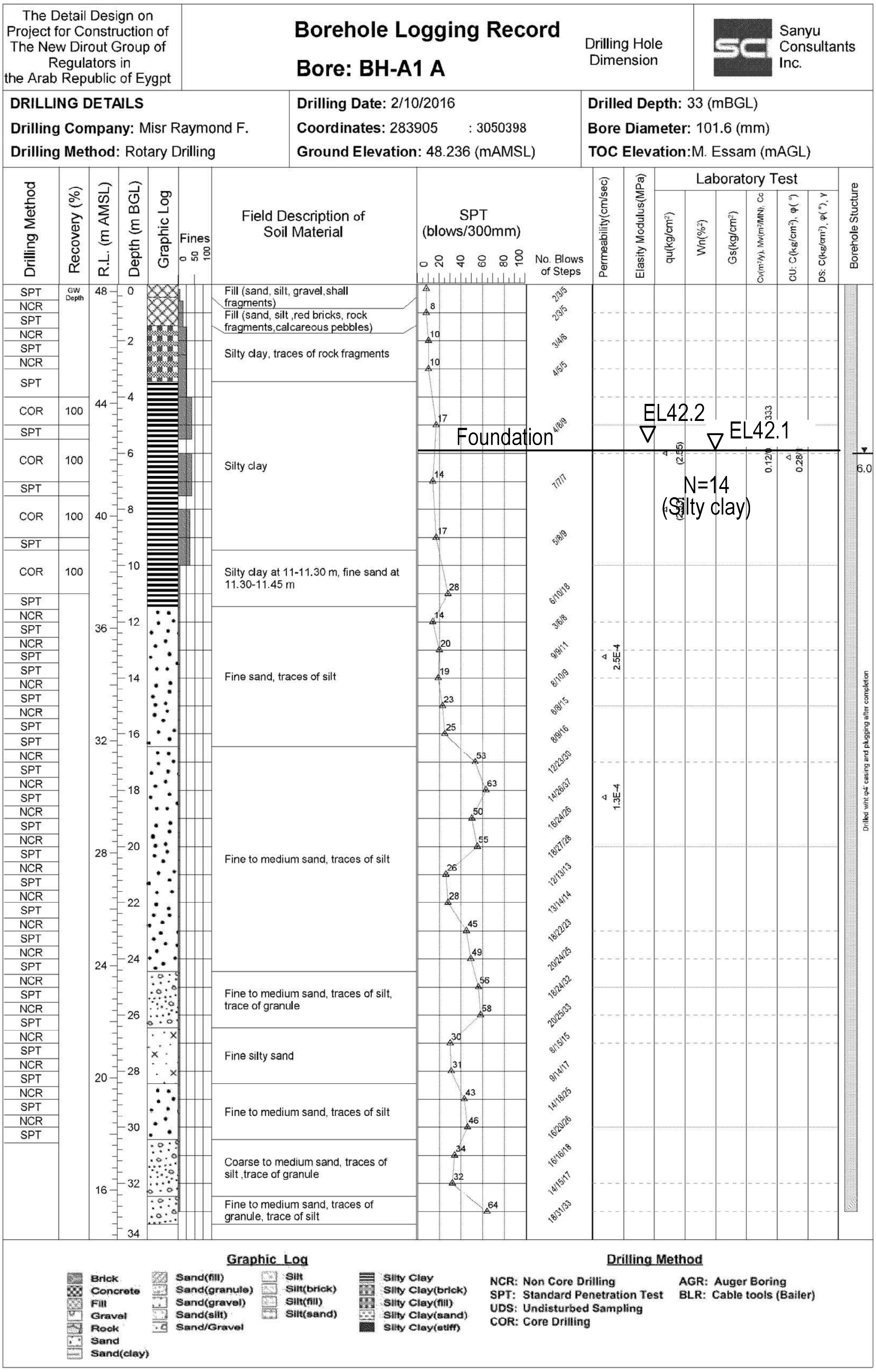
Drilled Depth: 33 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation: M.Rizk (mAGL)

Figure12-1.11 Br No. BH-A1B Badraman regulator (Badraman canal)

Badraman Regulator (Diroutiah canal)



The Detail Design on
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The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-A1 A

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS

Drilling Company: Misr Raymond F.

Drilling Method: Rotary Drilling

Drilling Date: 2/10/2016

Coordinates: 283905 : 3050398

Ground Elevation: 48.236 (mAMSL)

Drilled Depth: 33 (mBGL)

Bore Diameter: 101.6 (mm)

TOC Elevation:M. Essam (mAGL)

Field Description of Soil Material

- Fill (sand, silt, gravel,shall fragments)
- Fill (sand, silt ,red bricks, rock fragments,calcareous pebbles)
- Silty clay, traces of rock fragments
- Silty clay
- Silty clay at 11-11.30 m, fine sand at 11.30-11.45 m
- Fine sand, traces of silt
- Fine to medium sand, traces of silt
- Fine to medium sand, traces of silt, trace of granule
- Fine silty sand
- Fine to medium sand, traces of silt
- Coarse to medium sand, traces of silt ,trace of granule
- Fine to medium sand, traces of granule, trace of silt

Graphic Log

Brick
Concrete
Fill
Gravel
Rock
Sand
Sand(clay)
Sand(fill)
Sand(granule)
Sand(gravel)
Sand(silt)
Sand/Gravel
Silt
Silt(brick)
Silt(fill)
Silt(sand)
Silty Clay
Silty Clay(brick)
Silty Clay(fill)
Silty Clay(sand)
Silty Clay(stiff)

Drilling Method

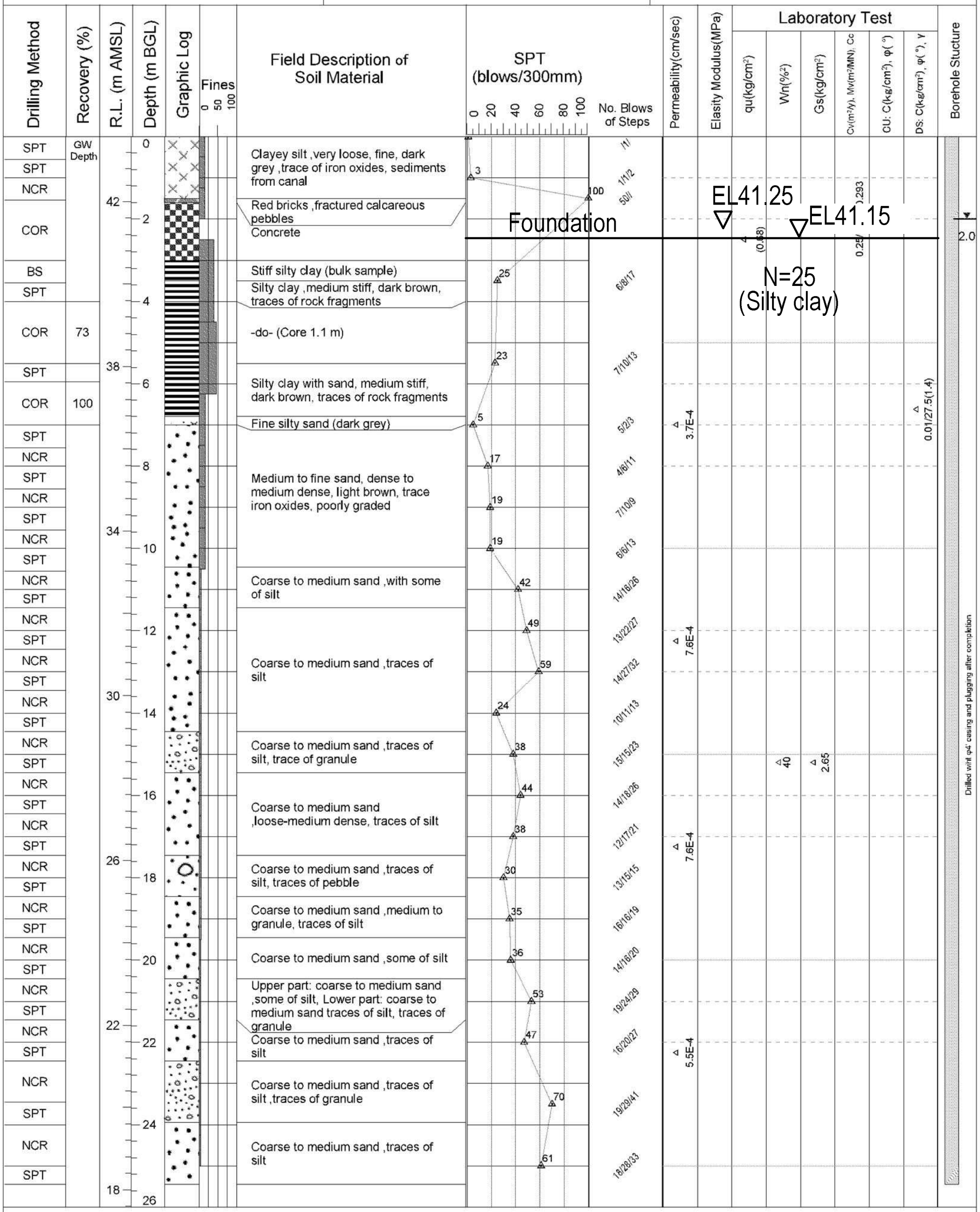
NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure12-1.12 Br No. BH-A1A Badraman regulator (Diroutiah canal)

Abo Gabal Regulator

The Detail Design on Project for Construction of The New Dirout Group of Regulators in the Arab Republic of Eygpt	**Borehole Logging Record** **Bore: BH-N5**	Drilling Hole Dimension	Sanyu Consultants Inc.

DRILLING DETAILS	**Drilling Date:** 12/13/2015	**Drilled Depth:** 27.45 (mBGL)
Drilling Company: Misr Raymond F.	**Coordinates:** 283870.09 : 3050163.25	**Bore Diameter:** 101.6 (mm)
Drilling Method: Rotary Drilling	**Ground Elevation:** 43.58 (mAMSL)	**TOC Elevation:**M. Essam (mAGL)



Clayey silt ,very loose, fine, dark grey ,trace of iron oxides, sediments from canal

Red bricks ,fractured calcareous pebbles

Concrete

Stiff silty clay (bulk sample)

Silty clay ,medium stiff, dark brown, traces of rock fragments

-do- (Core 1.1 m)

Silty clay with sand, medium stiff, dark brown, traces of rock fragments

Fine silty sand (dark grey)

Medium to fine sand, dense to medium dense, light brown, trace iron oxides, poorly graded

Coarse to medium sand ,with some of silt

Coarse to medium sand ,traces of silt

Coarse to medium sand ,traces of silt, trace of granule

Coarse to medium sand ,loose-medium dense, traces of silt

Coarse to medium sand ,traces of silt, traces of pebble

Coarse to medium sand ,medium to granule, traces of silt

Coarse to medium sand ,some of silt

Upper part: coarse to medium sand ,some of silt, Lower part: coarse to medium sand traces of silt, traces of granule

Coarse to medium sand ,traces of silt

Coarse to medium sand ,traces of silt ,traces of granule

Coarse to medium sand ,traces of silt

Graphic Log

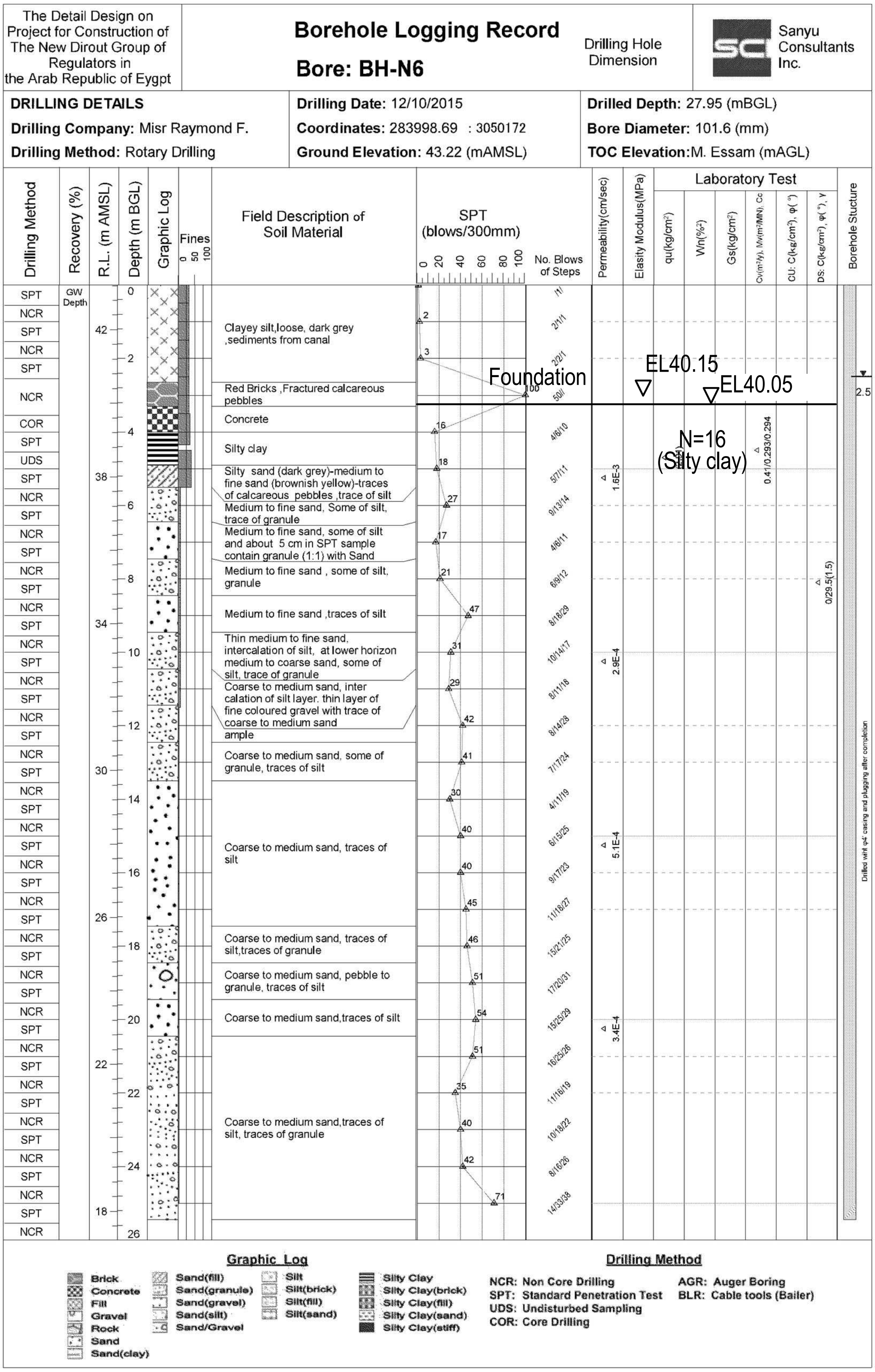
▨ Brick	▨ Sand(fill)	▨ Silt	▤ Silty Clay
▨ Concrete	▨ Sand(granule)	▨ Silt(brick)	▨ Silty Clay(brick)
▨ Fill	▨ Sand(gravel)	▨ Silt(fill)	▨ Silty Clay(fill)
▨ Gravel	▨ Sand(silt)	▨ Silt(sand)	▨ Silty Clay(sand)
▨ Rock	▨ Sand/Gravel		■ Silty Clay(stiff)
▨ Sand			
▨ Sand(clay)			

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure12-1.13 Br No. BH-N5 Abo Gabal regulator

Sahelyia Regulator



The Detail Design on
Project for Construction of
The New Dirout Group of
Regulators in
the Arab Republic of Eygpt

Borehole Logging Record

Bore: BH-N6

Drilling Hole Dimension

Sanyu Consultants Inc.

DRILLING DETAILS
Drilling Company: Misr Raymond F.
Drilling Method: Rotary Drilling
Drilling Date: 12/10/2015
Coordinates: 283998.69 : 3050172
Ground Elevation: 43.22 (mAMSL)
Drilled Depth: 27.95 (mBGL)
Bore Diameter: 101.6 (mm)
TOC Elevation:M. Essam (mAGL)

Field Description of Soil Material

Clayey silt,loose, dark grey ,sediments from canal

Red Bricks ,Fractured calcareous pebbles

Concrete

Silty clay

Silty sand (dark grey)-medium to fine sand (brownish yellow)-traces of calcareous pebbles ,trace of silt

Medium to fine sand, Some of silt, trace of granule

Medium to fine sand, some of silt and about 5 cm in SPT sample contain granule (1:1) with Sand

Medium to fine sand , some of silt, granule

Medium to fine sand ,traces of silt

Thin medium to fine sand, intercalation of silt, at lower horizon medium to coarse sand, some of silt, trace of granule

Coarse to medium sand, inter calation of silt layer. thin layer of fine coloured gravel with trace of coarse to medium sand ample

Coarse to medium sand, some of granule, traces of silt

Coarse to medium sand, traces of silt

Coarse to medium sand, traces of silt,traces of granule

Coarse to medium sand, pebble to granule, traces of silt

Coarse to medium sand,traces of silt

Coarse to medium sand,traces of silt, traces of granule

Drilled wint φ4' casing and plugging after completion

Drilling Method

NCR: Non Core Drilling
SPT: Standard Penetration Test
UDS: Undisturbed Sampling
COR: Core Drilling
AGR: Auger Boring
BLR: Cable tools (Bailer)

Figure12-1.14 Br No. BH-N6 Sahelyia regulator

(3) Results of primary selection of foundation

The large scale regulators of Bahr Yusef and Ibrahimia regulators which cannot take raft foundations must consider other foundation methods such as, soil improvement method, and pile foundation method. The conditions of the soil improvement method are shown in Table 12-1.5, and the evaluation of the available soil method is shown in Table 12-1.6. As a result of the evaluation, the soil improvement method selected for application is the ‘deep mixing treatment method. The conditions of the pile foundation method are the steel pipe pile, and cast-in-place RC pile shown in Tables12-1.7 and 12-1.8.

However, the Egyptian side strongly requested that the pre-casting concrete pile method be considered, as it is one of typical pile method in Egypt. In the response to their request, the pre-casting RC pile should be included in the methods evaluated.

Accordingly, the selected pile foundation and soil improvement methods for the final consideration were shown as follows.

Targeted foundation method after primary selection

- ✓ Soil improvement method: Deep mixing treatment method
- ✓ Pile foundation method: Steel pipe pile, cast-in-place RC pile, pre-casting RC pile

Table12-1.5 Site conditions related to foundation treatment works

Target facility / condition for selection		Bahr-Yusef Reg.		Ibrahimia Reg.	
		Weir Body	Downstream Apron L-shaped Retaining Wall	Weir Body	Downstream Apron L-shaped Retaining Wall
Ground condition	Soil property and layer thickness	・Approx. 4.0m downward from the foundation level: Medium to Coarse Sand ・Further 6.0m downward: Silty Clay (BH-N2D) *Those layers consist of the mixture of the construction waste and canal deposit, which makes a large variety in the property of the soil. Therefore, bearing layer has significant difference in its depth place by place.		・Approx. 5.0m downward from the foundation level: Fine sand and Silty Fine Sand (BH-N3')	
	Intermediate layer	Upper layer: Permeable Lower layer: Impermeable	Supposed to be the mixture of permeable and impermeable layers	Sand (Permeable) Layer	
	Bearing layer	Sand (Permeable) Layer		Sand (Permeable) Layer	
Impact on bank(e.g. differential settlement,etc.)		–	–	–	–
Construction condition	Construction depth	Approx. 11.0m		Approx. 7.0m	
	Construction period	It must be completed in the restricted time (relatively short period)		It must be completed in the restricted time (relatively short period)	
	Many past construction case examples	–	–	–	–
	Restricted work area	Double sheet pile method restricts the work space for the construction		Double sheet pile method restricts the work space for the construction	
	Poor trafficability	Low Workability due to the soft clay layer (N-value≦5) in some area on the foundation level (such as BH-N2')		–	–
Environmental condition	Low vibration, low noise	–	–	It is necessary to take measures against the vibration considering the railway and bank protection work with more than 10m height on the right bank.	
	Impact on groundwater	–	–	–	–
	Impact on adjacent structures	–	–	There is the railway and bank protection work with more than 10m height on the right bank	
	Deformation prevention of surrounding ground	–	–	There is the railway and bank protection work with more than 10m height on the right bank	
Advantage of the method		To strengthen the bearing capacity aruond the foundation		To strengthen the bearing capacity aruond the foundation	
Economy		Economic superior method is required for the selection		Economic superior method is required for the selection	

Table12-1.6 Available soil improvement method and its evaluation

Soil improuvement method								Bahr-Yusef Reg.								Bahr-Yusef Reg.							
								Weir body				L type wall				Weir body				L type wall			
Selection condition				Replacement method	Surface layer mixing treatment method	SCP method	Deep mixing treatment method	Replacement method	Surface layer mixing treatment method	SCP method	Deep mixing treatment method	Replacement method	Surface layer mixing treatment method	SCP method	Deep mixing treatment method	Replacement method	Surface layer mixing treatment method	SCP method	Deep mixing treatment method	Replacement method	Surface layer mixing treatment method	SCP method	Deep mixing treatment method
Ground condition	Soil property and layer thickness	Sandy soil	10m or less	△	○	○	△	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
			10m or more	×	×	○	△																
		Cohesive soil	10m or less	○	○	△	○	1	1	0	1	1	1	0	1								
			10m or more	×	×	△	○																
		Humus soil	3m or less	○	○	×	△																
			3m or more	×	×	△	△																
	Intermediate layer	Permeable layer exists		-	-	-	△				0				0				0				0
		Impermeable layer exists		-	-	○	○			1	1			1	1								
		Hard layer exists		-	-	△	△																
	Bearing layer	Can be considered as permeable layer		△	-	-	○	0			1	0			1	0			1	0			1
		Can be considered as impermeable layer		○	-	○	○																
Impact on bank(e.g. differential settlement,etc.)				○	△	△	△																
Construction condition	Construction depth	3m or less		○	○	×	△																
		3-10m		×	×	△	○									-2	-2	0	1	-2	-2	0	1
		10-20m		×	×	○	○	-2	-2	1	1	-2	-2	1	1								
		20-30m		×	×	△	○																
		30m or more		×	×	△	○																
	Construction period	Sufficiently long		○	○	△	△																
		Somewhat long		○	○	○	△																
		Short		○	○	△	○	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1
	Many past construction case examples			○	△	△	○																
	Restricted work area			×	×	△	△	−2	−2	0	0	−2	−2	0	0	−2	−2	0	0	−2	−2	0	0
	Poor trafficability			○	○	△	△	1	1	0	0	1	1	0	0								
Environmental condition	Low vibration, low noise			○	○	×	△									1	1	-2	0	1	1	-2	0
	Impact on groundwater			○	○	△	△																
	Impact on adjacent structures			○	○	×	○									1	1	-2	0	1	1	-2	0
	Deformation prevention of surrounding ground			○	○	△	○									1	1	−2	0	1	1	−2	0
Advantage of method	Settlement acceleration			-	-	○	-																
	Settlement prevention			○	○	-	○																
	Strength enhancement			○	○	○	○	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Embankment stabilization			○	○	○	○																
	Lateral flow prevention				○	△	○																
	Liquefaction prevention			○	○	○	△																
	Reduced permeability			△	○	×	△																
Economy				○	○	△	△	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0
								1	2	4	6	1	2	4	6	2	3	−4	4	2	3	−4	4

○: Fitted (1). △: Studies required (0). ×: Can be unfit (-2). -: Not applicable

Note: SCP method stands for sand compaction pile method.

Table12-1.7 Site conditions related to pile foundation works

Target facility / condition for selection			Bahr-Yusef Reg.		Ibrahimia Reg.	
			Weir Body	Downstream Apron L-shaped Retaining Wall	Weir Body	Downstream Apron L-shaped Retaining Wall
Ground condition	Condition to the bearing layer	Extremely soft layer exists in intermediate layer	Soft clay layer (N value≦5) is distributed around the Foundation depth（BH-N2'）		—	—
		Extremely stiff layer exists in intermediate layer	—	—	—	—
		Gravel exists in the intermediate layer	—	—	—	—
		Liquefiable layer exists	—	—	—	—
	Condition of bearing layer	Depth until bearing layer	Approx. 14.0m	Approx. 10.0m	Approx. 10.0m	Approx. 8.0m
		Soil property	Sand Layer		Sand Layer	
		Large dip（30 degree or more）	—	—	—	—
		Unevenness of bearing layer is severe	Bearing layer consists of the mixture of the construction waste and canal deposit, which makes a large variety in the property of the soil. Therefore, bearing layer has significant difference in its depth place by place.		—	—
	Condition of ground water		—	—	—	—
Structural features	Scale of load		Vertical load is normal. Lateral load is smaller than vertical load.	Vertical load is small. Lateral load is smaller than vertical load.	Vertical load is normal. Lateral load is smaller than vertical load.	Vertical load is small. Lateral load is smaller than vertical load.
	Support style		Bearing Pile	Bearing Pile	Bearing Pile	Bearing Pile
Construction condition	Underwater construction		—	—	—	—
	Narrow work space		Double sheet pile method restricts the work space for the construction		Double sheet pile method restricts the work space for the construction	
	Batter pile		—	—	—	—
	Impact of toxic gas		—	—	—	—
	Countermeasures against vibration and noise		—	—	It is necessary to take measures against the vibration considering the railway and bank protection work with more than 10m height on the right bank.	
	Impact on adjacent structures		—	—	There is the railway and bank protection work with more than 10m height on the right bank	

Table12-1.8 Available pile foundation method and its evaluation

							Bahr-Yusef Reg.						Ibrahimia Reg.					
							Weir body			L type wall			Weir body			L type wall		
			Pile foundation method	Driven pile		Cast-in-place RC pile	Driven pile		Cast-in-place RC pile	Driven pile		Cast-in-place RC pile	Driven pile		Cast-in-place RC pile	Driven pile		Cast-in-place RC pile
Selection condition				RC pile	Steel pipe pile		RC pile	Steel pipe pile		RC pile	Steel pipe pile		RC pile	Steel pipe pile		RC pile	Steel pipe pile	
Ground condition	Condition to the bearing layer	Extremely soft layer exists in intermediate layer		○	○	○	1	1	1	1	1	1						
		Extremely stiff layer exists in intermediate layer		×	△	○												
		Gravel exists in the intermediate layer	Gravel diameter: 5cm or less	△	○	○												
			Gravel diameter: 5～10cm	×	△	○												
			Gravel diameter: 10～50cm	×	×	×												
		Liquefiable layer exists		△	○	○												
	Condition of bearing layer	Depth until bearing layer	less than 5m	×	×	×												
			5～15m	○	○	△	1	1	0	1	1	0	1	1	0	1	1	0
			15～25m	○	○	○												
			25～40m	△	○	○												
			40～60m	×	○	○												
			60m or more	×	△	△												
		Soil property	Cohesive soil(20≦N)	○	○	○												
			Sand & Gravel(30≦N)	○	○	○	1	1	1	1	1	1	1	1	1	1	1	1
		Large dip（30 degree or more）		×	○	△												
		Unevenness of bearing layer is severe		△	○	○	0	1	1	0	1	1						
	Condition of ground water	Ground water level : close to ground surface		○	○	○												
		Spring volume : very large		○	○	○												
		Artesian groundwater: more than 2m from the ground surface		○	○	×												
		Velocity of groundwater: 3m/min or more		○	○	×												
Structural features	Scale of load	Vertical load is small		○	○	○				1	1	1				1	1	1
		Vertical load is average		△	○	○	0	1	1				0	1	1			
		Vertical load is large		×	○	○												
		Horizontal load is relatively small to vertical load		○	○	○	1	1	1				1	1	1			
		Horizontal load is relatively large to vertical load		×	○	○				−2	1	1				−2	1	1
	Support style	Bearing pile		○	○	○	1	1	1	1	1	1	1	1	1	1	1	1
		Friction pile		○	○	○												
Construction condition	Underwater construction	Water depth : less than 5m		○	○	○												
		Water depth : more than 5m		△	○	△												
	Narrow work space			△	△	△	0	0	0	0	0	0	0	0	0	0	0	0
	Batter pile			△	○	×												
	Impact of toxic gas			○	○	○												
	Surrounding circumstance	Countermeasures against vibration and noise		×	×	○							−2	−2	1	−2	−2	1
		Impact on adjacent structures		×	△	○							−2	0	1	−2	0	1
							5	7	6	3	7	6	0	3	6	−2	3	6

○: Fitted (1). △: Studies required (0). ×: Can be unfit (-2).

12-1-3 Result of the examination of thefoundation method

The primary selection of steel pile, and in-place concrete-pile foundation types available were compared for workability of construction and economy to decide which foundation type to use for the Bahr Yusef, Ibrahimia, and L type wall.

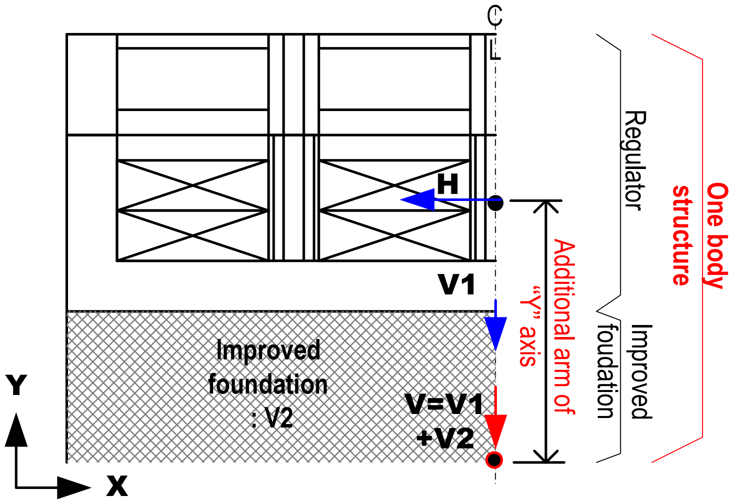


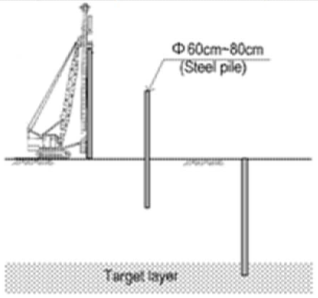
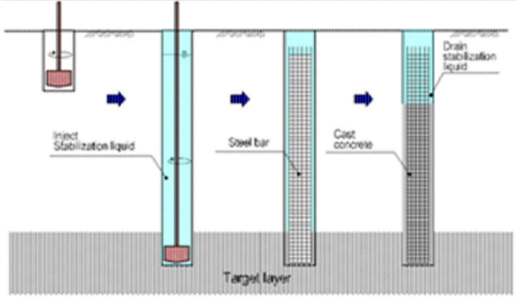
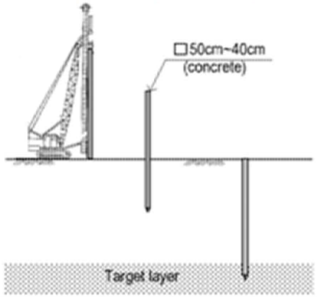
Figure12-1.15 Structural concept of deep mixing treatment method

As for the deep mixing treatment method, the improved soil foundation method considered the regulator and improved soil foundation to be one body structure. Therefore, the bottom layer of improved soil needed a certain bearing capacity to ensure stability.

However, the one body structure caused a long moment arm of horizontal force because of the depth of the improved soil. It increased moment by horizontal force. To ensure the long term stability of the bearing capacity of the bottom of the improved soil, a range of soil improvements should be considered. These are done not only through a theoretical equation, but by ensuring consecutive stable bearing layers observed from the actual borehole.

As a result of the evaluation, the cast-in-place RC pile was the foundation selected for the Bahr Yusef and Ibrahimia regulators, as well as the L type walls. These were approved at the 22nd TAC meeting, as they were deemed the most economically advantageous and have been successfully used before in Egypt. The same should be applied to the small, Badraman, Abo Gabal, and Sahelyia regulators.

Table12-1.9 Comparison table of pile foundation

Foundation type	Steel pipe pile (driven by vibro-hammer)	Cast-in-place RC pile (reverse circulation method)	Pre-cast concrete pile (driven by hammer)
Construction process		 Inject Stabilization liquid Steel bar Cast concrete Drain stabilization liquid Target layer	
Construction method	Driving the steel piles manufactured in the factory using a vibro-hammer into the ground until they reach the target layer. Both end-bearing and surface friction must be taken into consideration when accounting for allowable bearing capacity.	Constructing reinforced concrete piles in-place in the machine-drilled hole. Side surface of borehole is protected by the hydrostatic pressure of stabilization liquid. Both end-bearing and surface friction must be taken into consideration when accounting for allowable bearing capacity.	Driving the concrete piles made onsite by hammer into the ground until they reach the target layer. Both end-bearing and surface friction must be taken into consideration when accounting for allowable bearing capacity.
1. Reliability of Foundation (Evaluation) E: Excellent G: Good P: Poor	G: This is the type mostly used in Japan, but rarely used in Egypt. Therefore, lack of construction experience may be an issue. E: Since the steel is quality-controlled in the factory, high quality is ensured. P: Friction between the pile surface and the ground is smaller than that with concrete. E: High resilience to vertical and horizontal stress is expected. G: No corrosion will occur because piles are driven underground. G: It is possible to check the actual bearing capacity by reaction force during driving. 2points	E: This is the type mostly used in Egypt. Therefore, significant construction experience is expected. G: Concrete quality is relatively difficult to control onsite. E: The friction between the pile surface and the ground is the strongest of all three types, giving high stability to the foundation. E: High resilience to vertical and horizontal stress is expected. E: Pile does not corrode. G: It is possible to check the actual bearing capacity of the target layer using dug soil. 3points	E: This is the type mostly used in Egypt. Therefore, significant construction experience is expected. P: In the case of short piles (less than 5m), the quality of concrete is relatively easy to control onsite, but much harder for longer piles. P: Since the pile is shaped like a column, piles may be broken or damaged during driving work. P: High resilience to vertical stress and low resilience to horizontal stress are expected. E: Pile does not corrode. G: It is possible to check the actual bearing capacity by reaction force during driving. G: The friction between the pile surface and the ground is stronger than that with the steel pipe pile. 1point
2. Ease of Construction (Evaluation) E: Excellent G: Good P: Poor	E: Construction period is the shortest of all three options. E: Construction is not affected by groundwater level. P: Since the piles are transported from stockyard to site, special attention is required to prevent damages incurred en route, particularly to longer piles. G: Block-up by the soil can be generally expected, which makes the bearing capacity on the edge of piles, On the other hand, it is not usually considered in Egypt. Therefore, Enhancement works such as concrete injections may be necessary. E: Since the amount of soil replaced by driving the piles is the least of all three options, no treatment of dug soil is necessary.	P: Since this type requires more steps than the pile driving method, the required work period is longer. G: Borehole should be protected using stabilization liquid. In case groundwater level is very high, casing/stand pipes may be necessary to protect the dug hole, which elevates costs. E: Since the piles are made at the construction yard, there is no transportation impact. E: Pile length is easily adjustable depending on the depth of the borehole. P: Muddy water treatment and dug soil removal are required. G: The work yard is smaller than that in the pre-cast	P: The required work period and the number of piles are the most extensive of all three options. E: Construction is not influenced by groundwater level. P: Since the piles are transported from stockyard to site, special attention is required to prevent damages incurred en route (through vibration for instance), particularly to longer piles. E: Bearing capacity at the bottom of piles can be anticipated. E: Since very little soil is replaced by driving the piles, no treatment for dug soil is necessary. P: The work yard is the largest of all three options because of the concrete casting works required.

Foundation type		Steel pipe pile (driven by vibro-hammer)		Cast-in-place RC pile (reverse circulation method)		Pre-cast concrete pile (driven by hammer)	
		E: The work yard is the smallest of all three options. 3points		concrete pile. 2point		1point	
3. Environmental Aspect (Evaluation) E: Excellent G: Good P: Poor		G: Noise and vibration during driving are slightly more than when using cast-in-place concrete. G: Insignificant impact on adjacent structures. 2points		E: Noise and vibration are the lowest of all three options. E: Insignificant impact on adjacent structures. 3points		P: Noise and vibration are the highest of all three options. P: Impact on adjacent structures must be considered. 1point	
4. Economic Aspect Construction cost for foundation treatment (in Japanese Yen)		112,000,000 yen (ratio : 1.22) Note: materials in Egypt factored into above figure. 2points		92,000,000 yen (ratio : 1.00) Note: materials in Egypt factored into above figure. 3points		158,000,000 yen (ratio : 1.72) Note: materials in Egypt factored into above figure. 1point	
Name of Regulator		**Bahr Yusef regulator**	**Ibrahimia regulator**	**Bahr Yusef regulator**	**Ibrahimia regulator**	**Bahr Yusef regulator**	**Ibrahimia regulator**
Pile specifications	**regulator body**	φ600mm L=14.0m n=108 piles	φ600mm L=10.5m n=96 piles	φ1000mm L=14.0m n=70 piles	φ1000mm L=10.5m n=70 piles	□500mm L=14.0m n=156 piles	□500mm L=10.5m n=144 piles
	L-type wall	φ600mm L=8.5m n=84 piles (42 piles x2 locations)	φ600mm L=8.0m n=66 piles (33 piles x2 locations)	φ1000mm L=8.5m n=54 piles (27 piles x2 locations)	φ1000mm L=8.0m n=54 piles (27 piles x2 locations)	□500mm L=8.5m n=150 piles (75 piles x2 locations)	□500mm L=8.0m n=150 piles (75 piles x2 locations)
Construction period with one machine		1.4 month	1.2 month	3.5 month	3.5 month	1.9 month	1.9 month
		66,000,000	46,000,000	51,000,000	41,000,000	88,000,000	70,000,000
Evaluation		**Total points: 9 points** **Good** ✓This type has some good advantages but is inferior to the cast-in-place RC pile in terms of reliability of foundation and economy. ✓This method is rarely used in Egypt, therefore, lack of construction experience is a disadvantage.		**Total points: 11 points** **Excellent (recommended)** ✓This type has many good advantages such as reliability of foundation, environmental impact, and economy. ✓In addition, this is the method generally used in Egypt, therefore, construction experience is an advantage.		**Total points: 4 points** **Moderate** ✓Regardless of the advantages of this option, quality is less stable than in the other options.	

12-2 Specifications of piles

The pile diameters of the cast-in place RC piles available in Egypt are; 800mm, 900mm, 1,000mm, 1,100mm and 1,200mm. As the odd-numbered pile diameters 900mm and 1,100mm in size are difficult to find in Egypt, they are excluded from consideration. Accordingly, the available piles are 800mm, 1,000mm and 1,200mm in diameter.

The study of pile specifications takes both Egyptian and Japanese codes into consideration. The following tables shows the same basic loading condition as in the stability analysis and a comparison of both codes.

(1) Loading case

Table12-2.1 Loading condition for pile design sourced by stability analysis

Case	Condition	Direction	Water level			Gate situation	Additional condition
Case 1	Normal	Long.	U.S.	WL47.00m	HWL	Open gate	—
			D.S.	WL47.00m	HWL		
Case 2	Normal	Long.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case 3	Normal	Long.	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case 4	Normal	Lateral.	U.S.	WL46.55m	Max.WL	Open gate	—
			D.S.	WL46.55m	Max.WL		
Case 5	Normal	Lateral.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case 6	Normal	Lateral.	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case 7	Seismic	Long.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case 8	Seismic	Long.	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case 9	Seismic	Lateral.	U.S.	WL46.55m	Max.WL	Open gate	—
			D.S.	WL46.55m	Max.WL		
Case 10	Seismic	Lateral.	U.S.	WL46.55m	Max.WL	Close gate	sedimentation (0.3m depth)
			D.S.	WL39.50m	Low		
Case 11	Seismic	Lateral.	U.S.	—	No WL	Open gate	—
			D.S.	—	No WL		
Case 12	Seismic	Long.	U.S.	WL46.55m	Max.WL	Open gate	—
			D.S.	WL46.55m	Max.WL		
Case 13	Normal (Maintenance)	Long.	U.S.	WL46.55m	Max.WL	Maintenance gate	—
			D.S.	WL45.82, 45.13m	Low		

※Maximum operation water level at U.S. is same as head level of gate (WL46.30 + 0.25m＝EL46.55) to ensure safety

※At fully closed gate situation, water level at D.S. is same as apron level（EL39.5）.

(2) Method of evaluation of vertical bearing capacity and pull-out strength

The safety ratio between the calculated vertical bearing capacity and pull-out strength is considered in the table below.

Table12-2.2 Safety ratio for vertical bearing capacity and pull-out strength

	Japanese code		Egyptian code (applied)	
Pile conditions	vertical bearing capacity	pull-out strength	vertical bearing capacity	pull-out strength
Normal	3	6	3	3
Seismic	2	3	2	2

i) Examination of vertical bearing capacity

The vertical bearing capacity for one pile is calculated using the following equation.

Japanese code

$$Ra = \frac{1}{n}(Ru - Ws) + Ws - W$$

Where, Ra: vertical allowable bearing capacity (downward) at pile head (kN/pile)
Ru: ultimate bearing capacity of pile determined by the foundation（kN/ pile）
Ws: effective mass of soil replaced by pile（kN）
W: effective mass of pile and soil inside of the pile（kN）
n: Safety ratio

a. Ru: Ultimate bearing capacity of pile determined by the foundation

Bearing capacity is estimated using the following formula.

$$Ru = qd \cdot A + U \cdot \Sigma Li \cdot fi$$

Where, Ru: ultimate bearing capacity of pile determined by the foundation（kN/ pile）
A: area of pile tip (m^2)
qd: ultimate bearing capacity of pile tip per unit area（kN/m^2）
U: circumference of pile（m）
Li: penetration depth for surface friction layer（m）
fi: maximum surface friction per unit area for surface friction layer（kNm^2）

Egyptian code (applied)

$$Ra = \frac{1}{n}(Ru - P)$$

b. Estimation of ultimate bearing capacity per unit area of pile tip (qd)

Table12-2.3 Ultimate bearing capacity per unit area of pile tip (Unit: kN/m^2)

	Japanese code	Egyptian code
Driven method / Foundation type	In-placed con-pile	In-placed con-pile
Gravelly layer and sandy layer (N > 30)	3,000	90N (include safety ratio)
Sturdy gravelly layer (N > 50)	5,000	90N (include safety ratio)
Hard cohesive soil	3qu	9 C

qu: unconfined compressive strength (kN/m^2)
N: N value (SPT)

c. Calculation of maximum surface friction per unit area (fi)

Table12-2.4 Surface friction per unit area (Unit: kN/m^2)

	Japanese code		Egyptian code	
Driven method / Foundation type	Driven pile	In-placed con-pile	Driven pile	In-placed con-pile
Sand	2N（≦100）	5N（≦200）	N (include safety ratio)	N (include safety ratio)
Clay	C or 10N（≦150）	C or 10N（≦150）	C（≦100）	0.4C（≦100）

Note: Due to inaccuracy, it is assumed that there is no surface friction under the soft layer condition (N≦2).

The vertical bearing capacity in the Egyptian code is between “soil failure" and "settlement of pile." The applied allowable displacement on the settlement of regulators is between 50mm to

60mm per pile and should be considered in pile design.

ii) Examination of pull-out direction

The pull-out direction per pile unit can be obtained by the formula below.

Japanese code

$$Pa = \frac{1}{n} Pu + W$$

Where Pa: vertical allowable pull-out strength at pile head (kN/pile)
n: safety ratio (refer Table 2-6-2.1)
Pu: ultimate pull-out strength of pile determined by the foundation (kN/pile)
W: effective mass of pile (kN/pile)

"Pa" must be less than the allowable tensile capacity in axis direction. "Pu" is calculated using the following equation (function of the maximum surface friction per unit area), according to the second paragraph of the equation for ultimate bearing capacity as follows.

$$Pu = U \cdot \Sigma Li \cdot fi$$

Egyptian code (applied)

$$Pa = \frac{1}{n} Pu + P$$

iii) Allowable bearing capacity by pile type

Japanese code

$$P = \sigma \cdot A$$

Where P: allowable bearing capacity by the type of pile（N）
σ: allowable stress of pile itself（N/mm^2）
A: sectional area of pile（mm^2）

Egyptian code (applied: same as Japanese code)

$$P = \sigma \cdot A$$

(3) Method of counterforce against pile and displacement of footing

Japanese code

This is calculated using the "displacement method" that assumes the following conditions.

- ✓ Pile foundation is a two-dimensional structure.
- ✓ Pile is linear elastic given any force such as pushing, pulling and bending. Vertical, horizontal, and rotational spring are constant values regardless of load at the pile head. A value accounting for the pushing and pull-out is applied to the spring constant.
- ✓ Footing is the rigid body, and the center of rotation is the centroid of group piles.

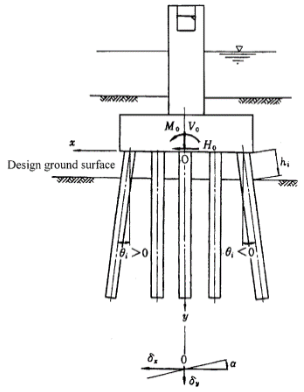


Figure 12-2.1 Model of displacement method

Egyptian code (applied)

It is the same as Japanese code

(4) Design of pile body and layout

The calculations arrived at by the displacement method provide the horizontal force and moment that act on the pile, and as such must be taken into consideration in pile body design.

Table 12-2.5: Allowable stress of pile (Egyptian code)

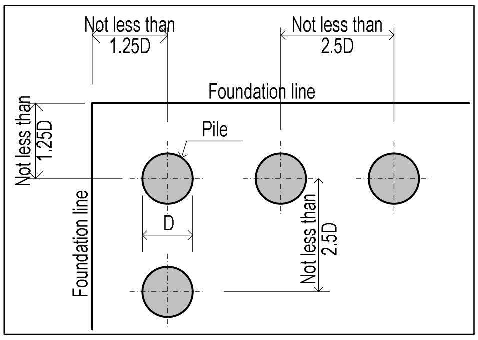
Pile type	Normal	Seismic
In-placed con-pile	σc: 9.5N/mm^2 σs: 200N/mm^2	σc: 10.9N/mm^2 σs: 230N/mm^2

The allowable stress of steel pile is applied to the Egyptian figures provided in the working group meeting, shown in Table 12-2.5. In addition, 15mm allowable horizontal displacement at pile head is applied. This figure is sourced from the Japanese standard since there is no figure provided in the Egyptian code.

(5) Pile layout

Layout should follow Japanese standards, as their underlying concept is to avoid the negative impact of the interaction of closely set piles. The minimum distance between piles is shown in Table 12-2.6.

Table 12-2.6: Necessary distance between piles

Japanese code	Egyptian code
 Not less than 1.25D Not less than 2.5D Foundation line Pile Not less than 1.25D D Foundation line Not less than 2.5D	✓ Spacing between piles is no less than 2.5 D for bearing piles. (←our case) ✓ Spacing between piles is no less than 3.0 D for friction piles.

12-3 Results of pile foundation design

The design method of the pile foundation in both the Egyptian and the Japanese codes applies the displacement method. Therefore, the number of piles should be in accordance with the Japanese code because the design method was consolidated according to the Egyptian code. After that, the number of piles arrived at by the Japanese code should be re-evaluated against the Egyptian code.

The pile foundation designs are shown in Table 12-3.1, and Figures 12-3.1, and 12-3.2. The comparison between piles is shown in Tables 12-3.2 and 12-3.3.

Table12-3.1 Specifications of pile design at Bahr Yusef and Ibrahimia regulators

Structure	Nos. of piles	dia.	Length of piles	note
Bahr Yusef regulator	8x9=72	1,000mm	13.5m	Cast in-place concrete pile
Ibrahimia regulator	7x8=56	1,000mm	15.0m	Cast in-place concrete pile
Bahr Yusef L-type wall	2x8=16	1,000mm	7.5m	Cast in-place concrete pile
Ibrahimia L-type wall	2x8=16	1,000mm	7.0m	Cast in-place concrete pile

Table12-3.2 Comparison table of economic pile specifications at Bahr Yusef and Ibrahimia regulators

Bahr Yusef Reg

Dia pile	weir dir.	flow dir.	length	Compressive(kN/pile) : normal			Stress in pile body(kN/mm2) : seismic						Dia. Steel	nos./pile	Cost(LE)
(mm)			(m)	Actual		Allowable	σc		σca	σs		σsa	(mm)		
800	10	9	14.0	1,587.25	<	1,598.97	10.15	<	10.93	108.48	<	230	φ32	17	3,758,629
1,000	8	7	16.5	2,540.21	<	2,601.60	10.17	<	10.93	122.35	<	230	φ32	20	3,460,204
1,000	9	8	13.5	1,981.25	<	1,993.31	10.67	<	10.93	174.29	<	230	φ25	14	2,855,727
1,000	10	9	12.0	1,587.37	<	1,706.45	9.58	<	10.93	175.87	<	230	φ33	11	3,372,756
1,200	7	6	17.5	3,378.20	<	3,474.82	10.69	<	10.93	158.83	<	230	φ32	16	3,105,815
1,200	8	7	14.5	2,539.51	<	2,749.67	10.51	<	10.93	219.82	<	230	φ22	15	2,922,933
1,200	9	8	12.0	1,978.99	<	2,179.94	8.31	<	10.93	169.55	<	230	φ22	14	3,107,958

Ibrahimia Reg

Dia pile	weir dir.	flow dir.	length	Compressive(kN/pile) : normal			Stress in pile body(kN/mm2) : seismic						Dia. Steel	nos./pile	Cost(LE)
(mm)			(m)	Actual		Allowable	σc		σca	σs		σsa	(mm)		
800	9	8	15.0	1,980.17	<	2,029.80	10.40	<	10.93	99.49	<	230	φ32	17	3,237,118
800	10	9	12.5	1,590.93	<	1,635.84	10.77	<	10.93	126.61	<	230	φ32	8	2,649,235
1,000	7	6	19.0	3,381.66	<	3,424.72	10.85	<	10.93	116.92	<	230	φ32	23	3,167,174
1,000	8	7	15.0	2,540.71	<	2,633.03	10.24	<	10.93	126.34	<	230	φ25	11	2,365,002
1,000	9	8	12.0	1,981.55	<	2,057.73	10.21	<	10.93	168.11	<	230	φ22	11	2,375,476
1,000	10	9	10.0	1,585.93	<	1,668.96	8.13	<	10.93	133.46	<	230	φ22	11	2,507,964
1,200	6	5	21.0	4,583.53	<	4,697.98	10.23	<	10.93	118.18	<	230	φ32	30	3,307,029
1,200	7	6	15.5	3,378.49	<	3,395.82	9.36	<	10.93	124.22	<	230	φ32	15	2,753,879
1,200	8	7	12.0	2,541.10	<	2,591.17	8.72	<	10.93	149.02	<	230	φ22	15	2,497,987
1,200	9	8	9.5	1,979.09	<	2,003.85	6.78	<	10.93	115.84	<	230	φ22	15	2,593,857

L type wall - Bahr Yusef

Dia pile	weir dir.	flow dir.	length	Compressive(kN/pile) : normal			Stress in pile body(kN/mm2) : normal						Dia. Steel	nos./pile	Cost(LE)
(mm)			(m)	Actual		Allowable	σc		σca	σs		σsa	(mm)		(2sets)
800	3	9	7.0	592.62	<	655.25	9.482	<	9.50	199.36	<	200	φ32	15	1,345,516
800	3	10	7.0	533.36	<	655.25	8.846	<	9.50	190.66	<	200	φ32	14	1,432,117
800	3	11	6.5	484.87	<	622.45	8.543	<	9.50	189.07	<	200	φ32	13	1,437,768
1,000	2	8	7.5	942.88	<	1,030.99	9.075	<	9.50	193.50	<	200	φ32	24	1,001,270
1,000	3	6	7.5	970.36	<	1,030.99	7.898	<	9.50	199.56	<	200	φ32	20	1,280,000
1,000	3	7	7.0	840.99	<	892.24	7.333	<	9.50	194.10	<	200	φ32	18	1,335,494
1,000	3	8	7.0	735.87	<	892.24	6.854	<	9.50	189.52	<	200	φ25	25	1,418,760
1,200	2	7	7.0	1,138.51	<	1,158.81	7.579	<	9.50	199.88	<	200	φ32	26	1,255,522
1,200	2	8	7.0	996.19	<	1,158.81	7.026	<	9.50	196.46	<	200	φ32	23	1,342,969
1,200	3	5	8.0	1,252.37	<	1,874.66	6.353	<	9.50	193.99	<	200	φ32	23	1,397,025
1,200	3	6	7.5	1,058.50	<	1,206.69	5.913	<	9.50	194.678	<	200	φ25	30	1,453,547
1,200	3	7	7.0	920.04	<	1,158.81	5.641	<	9.50	195.784	<	200	φ25	26	1,513,867
1,200	3	8	7.0	805.04	<	1,158.81	5.282	<	9.50	191.901	<	200	φ25	23	1,642,201

L type wall - Ibrahimia

Dia pile	weir dir.	flow dir.	length	Compressive(kN/pile) : normal			Stress in pile body(kN/mm2) : normal						Dia. Steel	nos./pile	Cost(LE)
(mm)			(m)	Actual		Allowable	σc		σca	σs		σsa	(mm)		(2sets)
800	3	9	6.5	568.17	<	684.15	9.424	<	9.50	185.316	<	200	φ32	17	1,341,216
800	3	10	6.5	511.35	<	684.15	9.327	<	9.50	197.787	<	200	φ32	14	1,362,997
800	3	11	6.5	464.87	<	684.15	8.809	<	9.50	191.898	<	200	φ32	13	1,437,768
					<			<			<				
1,000	2	8	7.0	827.66	<	1,480.96	7.675	<	9.50	199.042	<	200	φ32	24	939,146
1,000	3	6	7.0	936.20	<	1,480.96	8.064	<	9.50	190.875	<	200	φ32	22	1,264,796
1,000	3	7	7.0	802.46	<	1,480.96	7.563	<	9.50	196.156	<	200	φ32	18	1,335,494
1,000	3	8	6.0	712.16	<	726.90	7.459	<	9.50	197.304	<	200	φ32	17	1,318,850
					<			<			<				
1,200	2	7	6.5	1,121.57	<	1,329.64	8.004	<	9.50	198.258	<	200	φ32	28	1,226,587
1,200	2	8	6.0	997.83	<	1,069.70	7.772	<	9.50	199.189	<	200	φ32	27	1,278,857
1,200	3	5	7.0	1,251.10	<	1,905.13	6.664	<	9.50	191.900	<	200	φ32	25	1,309,795
1,200	3	6	6.5	1,073.20	<	1,329.64	6.270	<	9.50	192.222	<	200	φ32	22	1,386,235
1,200	3	7	6.0	953.49	<	1,069.70	6.180	<	9.50	196.646	<	200	φ25	31	1,429,321
1,200	3	8	6.0	834.31	<	1,069.70	5.839	<	9.50	195.440	<	200	φ25	27	1,536,095

Table12-3.3 Pile bearing capacity according to Egyptian code
(Comparison between "soil failure" and "settlement of pile")

	EGY code										
			Qallowable according to soil failure								**Qallowable by settelement**
	Dia	Length	**Bearing capacity at pile end**			**Pile friction capacity**				**Qallowable by soil failure**	
			Bearing range	N	Qb-allowable	Friction range	N ave. F	safe factor	Qb-allowable		
	(mm)	(m)	(m)	ave. of Be. rabge	(kN)	(m)	ave. of Fr. rabge	for SPT	(kN)	(kN)	**(50 - 60) mm (kN)**
Bahr Yusef	1,000	13.5	4.00	40.0	2,827.4	8.5	13.6	1	363.2	**3191**	**1778 - 2051 (applied)**
Ibrahimia	1,000	15.0	4.00	40.0	2,827.4	10.0	26.2	1	823.1	**3651**	**2382 - 2776 (applied)**

Table12-3.4 Comparison between bearing capacity in Egyptian code and Japanese code

	Egyptian code Allowable bearing capacity by settlement (kN/pile)	Japanese code Allowable bearing capacity by soil failure (kN/pile)	Judgement
Bahr Yusef	less than 2051	1993.31(reg.), 1030.99(L type)	Allowable bearing capacities by Japanese code are less than "allowable by soil failure" by Egyptian code and allowable one by Japanese are within the allowable one by settlement in Egyptian code. Therefore the pile arrangement by its designs are acceptable and complied with Egyptian code.
Ibrahimia	less than 2776	2,633.03(reg.), 1480.96(L type)	

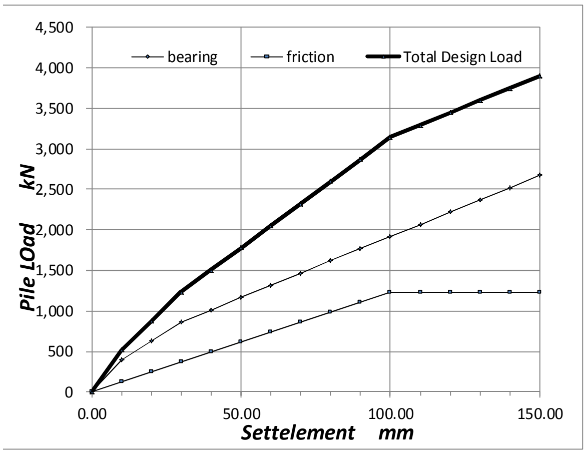
Table12-3.5 Bearing capacity for target settlement

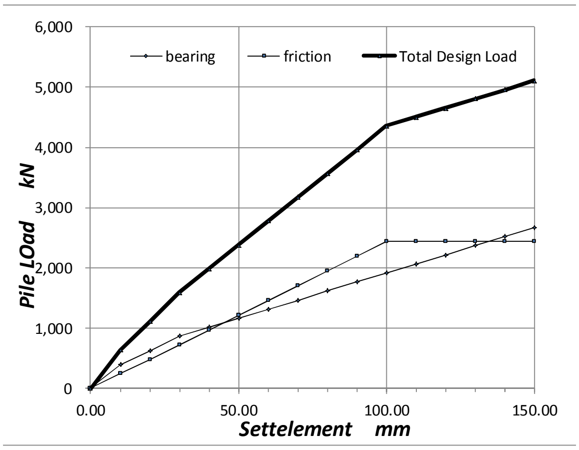
Bahr Yusef

Design Settlement (mm)	Allowable bearing capacity per unit for design settlement	Bearing capacity kN/pile	Friction on surface kN/pile	**Total Load** kN/pile	Allowable B.C. by JP code kN/pile	Assumed settlement (mm)
0		0	0	**0**		50mm-60mm
10	5	393	123	**515**		
20	8	628	245	**873**		
30	11	864	368	**1,232**		
40	13	1,014	490	**1,505**		
50	15	1,165	613	**1,778**	**1993**	**57.9**
60	17	1,316	735	**2,051**		
70	19	1,466	858	**2,324**		
80	21	1,617	980	**2,597**		
90	23	1,767	1,103	**2,870**		
100	24	1,918	1,225	**3,143**		
110	26	2,068	1,225	**3,293**		
120	28	2,219	1,225	**3,444**		
130	30	2,369	1,225	**3,595**		
140	32	2,520	1,225	**3,745**		
150	34	2,670	1,225	**3,896**		

Ibrahimia

Design Settlement (mm)	Allowable bearing capacity per unit for design settlement	Bearing capacity kN/pile	Friction on surface kN/pile	**Total Load** kN/pile	Allowable B.C. by JP code kN/pile	Assumed settlement (mm)
0		0	0	**0**		50mm-60mm
10	5	393	243	**636**		
20	8	628	487	**1,115**		
30	11	864	730	**1,594**		
40	13	1,014	974	**1,988**		
50	15	1,165	1,217	**2,382**	**2633**	**56.4**
60	17	1,316	1,461	**2,776**		
70	19	1,466	1,704	**3,170**		
80	21	1,617	1,948	**3,564**		
90	23	1,767	2,191	**3,958**		
100	24	1,918	2,435	**4,352**		
110	26	2,068	2,435	**4,503**		
120	28	2,219	2,435	**4,653**		
130	30	2,369	2,435	**4,804**		
140	32	2,520	2,435	**4,955**		
150	34	2,670	2,435	**5,105**		





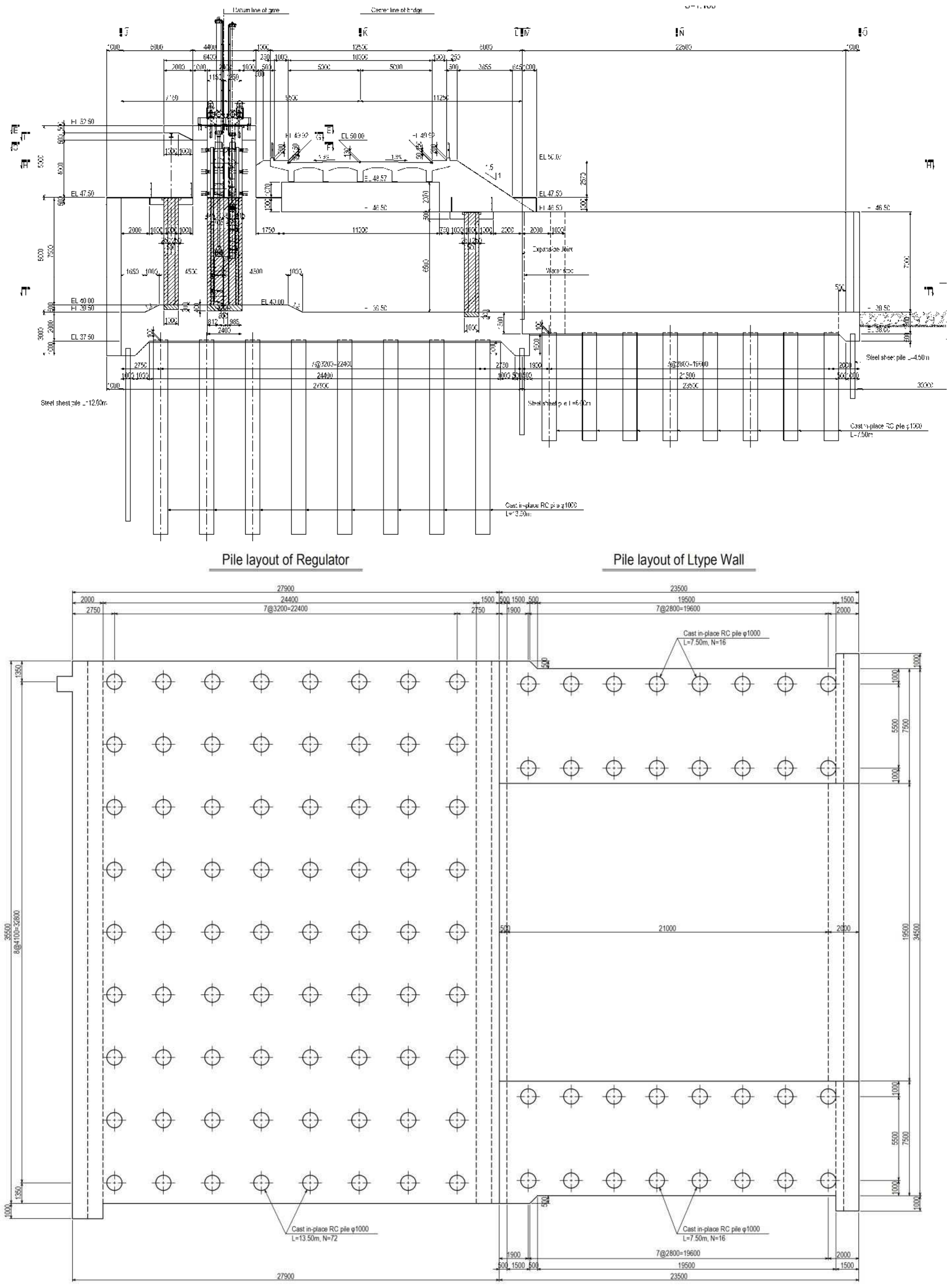
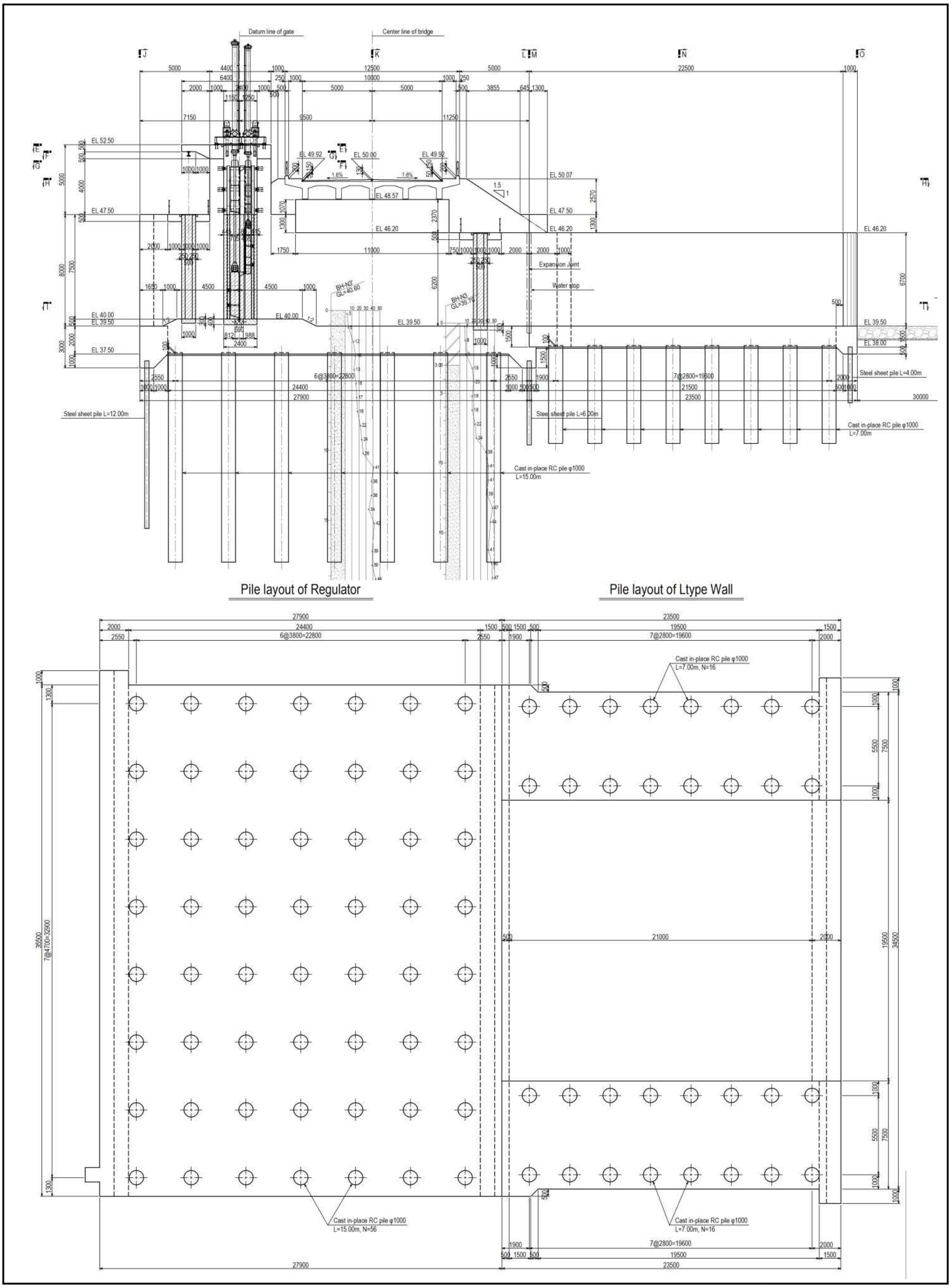


Figure12-3.1 Pile layout and design of Bahr Yusef regulator and L-type wall



Pile layout of Regulator

Pile layout of Ltype Wall

Figure12-3.2 Pile layout and design of Ibrahimia regulator and L-type wall

13. Design of Bank Protection Works

13-1 Selection of construction method

The bank protection principally depends on the surface conditions of the construction area. The steel sheet pile method is applied in the area where it is hard to work with cofferdam in dry conditions, whereas the stone pitching method is applied in the area where it is possible to work in dry conditions.

As the results of the 3D flow analysis and the hydraulic model study done by Egyptian side, it was confirmed that vortexes were generated on downstream left bank of the Bahr Yusef Regulator and on the downstream right bank of the Ibrahimia Regulator. Therefore, it was decided to shape the flow channels by embankments as a solution to minimize the vortexes. Through the comparative analysis regarding the engineering methods as described below, the gabion construction method was chosen for the bank protection method at these embankments.

13-2 Design of steel sheet pile work

(1) Policy to select type of steel sheet pile work

Considering the shape of the structure, conditions of the foundation, workability and construction costs, the free-standing cantilever selected steel sheet pile method is best. From a safety perspective, tie-rod steel sheet pile method can be also selected in case the free-standing cantilever sheet pile does not have enough stability considering its structure.

(2) Cross-sectional map for steel sheet pile

There are thirteen types to be considered, all shown in Figure 13-2.1.

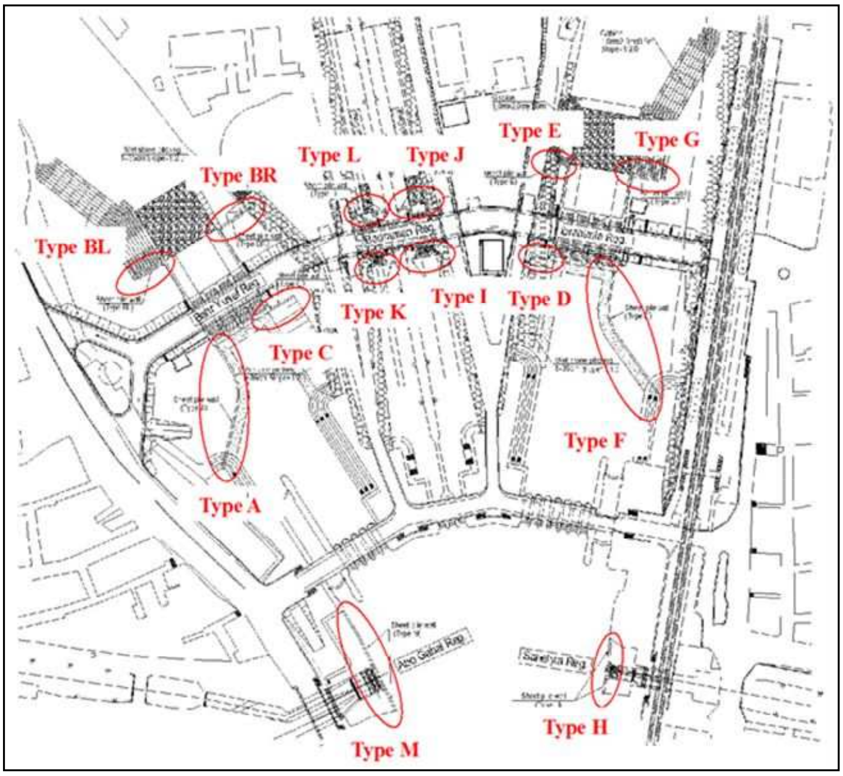


Figure13-2.1 Location map for each type of sheet pile

(3) Type and scale of the sheet pile method

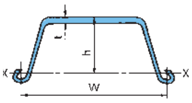
① Steel materials in use

Upon the supply of the steel materials (e.g. steel sheet piles, steel channel and tie-rods) for the sheet pile construction work, tie-rods including attachment are procured from Japan based on the results of the study of materials procurement, and other materials supplied by the third party countries where Egypt has the procurement record thereof.

The steel sheet piles that were adopted were procured from ArcelorMittal, the world's largest steel manufacturer, having its main office in Luxemburg. The cross-sectional performance and the specifications of the steel sheet piles in use are shown in Table 13-2.1 and in Table 13-2.2 respectively.

Table 13-2.1 Sectional performance of steel sheet piles

S



	Type	Width	Height	Thickness	Sectional area	Mass		Moment of inertia	Elastic section modulus
						single pile	wall		
		w mm	h mm	t mm	A cm^2/m	kg/m	kg/m^2	I cm^4/m	Z cm^3/m
Steel Sheet pile	PU12	600	180	9.8	140.0	66.1	110	21,600	1,200
	PU18	600	215	11.2	163.0	76.9	128	38,650	1,800
	PU22	600	225	12.1	183.0	86.1	144	49,460	2,200
	PU28	600	227	15.2	216.0	101.8	170	64,460	2,840
	PU32	600	226	19.5	242.0	114.1	190	72,320	3,200
Reference (Japan)	SP-Ⅱw	600	130	10.3	131.2	61.8	103	13,000	1,000
	SP-Ⅲw	600	180	13.4	173.2	81.6	136	32,400	1,800
	SP-Ⅳw	600	210	18.0	225.5	106.0	177	56,700	2,700

Table 13-2.2 Specifications of steel materials

	Grade	Yield point	Tensile Strength	Allowable Stress
		N/mm^2	N/mm^2	N/mm^2
Steel Sheet pile	S270GP	270	410	165
	S320GP	320	440	195
	S355GP	355	480	215
	S390GP	390	490	235
	S430GP	430	510	260
Reference (Japan)	SY295	295	490	180
	SY390	390	540	235

② Design method of steel sheet pile work

The design method of steel sheet pile work is different depending upon the structure types and many design methods have been proposed. In this design, the following design methods were used:

- The free-standing cantilever steel sheet pile method: Y. L. Chang's formula
- Tie-rod steel sheet pile method: Free earth support method

On the corrosion-resistant protection of the steel sheet piles, it was confirmed to use the "Corrosion-resistant Coating Method" that is widely used in Egypt through the discussions with the Design WG,. Therefore, no cost of corrosion-resistant protection was considered in the design.

For the tie-rod steel sheet pile method, it is necessary to construct the embankments by installing the brace type steel sheet piles in the embankments in order to secure the structural safety of the tie-rod steel sheet pile work. The steps of the tie-rod type steel sheet pile work and embankment work are shown in Figure 13-2.2.

Therefore, the design of the tie-rod steel sheet pile work is conducted including the design of the completed form and the design in the conditions that the front steel sheet piles are in free-standing state during the construction and the primary embankment form is also set.

The results of examination of the steel sheet pile work are shown in Table 13-2.3 to Table 13-2.5 and Figure 13-2.3 to Figure 13-2.5.

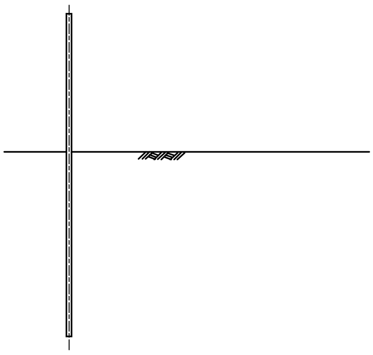
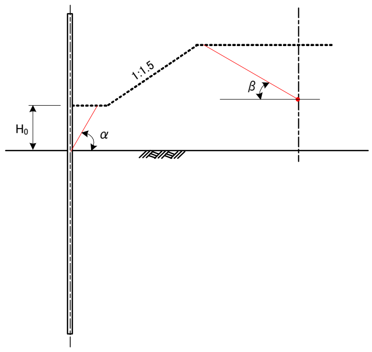
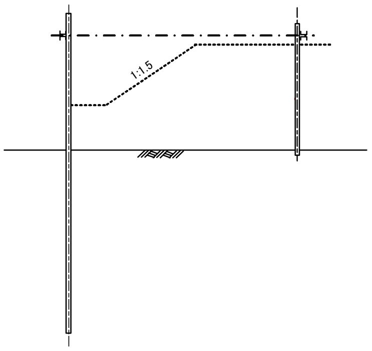
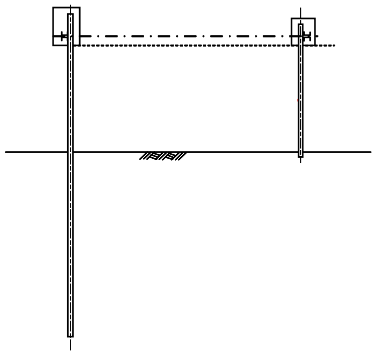
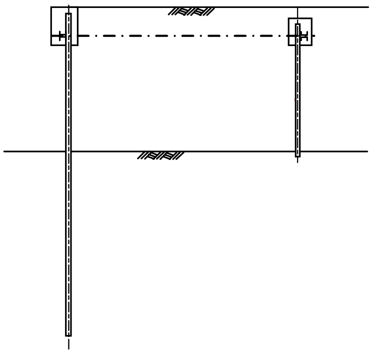
Step 1 	**Step 2** 
● Place the front steel sheet pile.	● Construct the primary embankment. The embankment is constructed at the height (H_0) to secure the safety of the free-standing front steel sheet pile, and formed so as to give no further impact of the embankment weight on the domain within the active collapse angle (α). The section in the level of passive collapse angle (β) or larger is secured to expect the passive earth pressure for the brace type steel sheet pile.
Step 3 	**Step 4** 
● Install the tie-rod and waling material.	● Construct the secondary embankment and the head concrete.
Step 5 	
● Construct the embankment up to the planed height and complete it.	

Figure 13-2.2 Construction procedure of tie-rod type steel sheet pile work

Table13-2.3 Result of the consideration for bank protection works (1/3)

Regulator Name		New Bahr Yusef Regulator																			
Type		A			BL-1			BL-2		BR-1			BR-2			C-1			C-2		
Construction Length		66.60m			6.60m			6.60m		4.80m			9.00m			3.60m			9.00m		
Sheet Pile Type		Tie-Rod			Tie-Rod			Free-standing cantilever		Tie-Rod			Tie-Rod			Tie-Rod			Tie-Rod		
		Long time	Sort time (Seismic)	During construction (H=3.00m)	Long time	Sort time (Seismic)	During construction (H=2.00m)	Long time	Sort time (Seismic)	Long time	Sort time (Seismic)	During construction (H=2.00m)	Long time	Sort time (Seismic)	During construction (H=3.50m)	Long time	Sort time (Seismic)	During construction (H=3.50m)	Long time	Sort time (Seismic)	During construction (H=4.00m)
Front	Model	PU18			PU18			PU18		PU18			PU18			PU18			PU18		
sheet pile	Length m	21.50			16.50			11.00		16.50			11.50			19.00			17.00		
	Stress N/mm^2	157 (<165)	86 (<190)	35 (<165)	114 (<165)	60 (<190)	40 (<165)	78 (<165)	60 (<190)	114 (<165)	61 (<190)	40 (<165)	25 (<165)	17 (<190)	63 (<165)	157 (<165)	86 (<190)	48 (<165)	41 (<165)	36 (<190)	67 (<165)
	Penetration m	14.20			9.70			7.70		9.70			7.20			11.70			12.20		
	depth	(>14.14)	(>7.58)	(>7.29)	(>9.38)	(>5.51)	(>7.57)	(>7.47)	(>7.55)	(>9.38)	(>5.52)	(>7.57)	(>6.80)	(>5.49)	(>7.15)	(>11.58)	(>7.92)	(>6.87)	(>12.10)	(>11.31)	(>7.06)
	Horizontal mm displacement			29.48 (<50.00)			32.72 (<50.00)	35.12 (<50.00)	27.70 (<75.00)			32.72 (<50.00)			32.38 (<50.00)			39.04 (<50.00)			40.56 (<50.00)
Bracing	Model	PU12			PU12					PU12			PU12			PU12			PU12		
sheet pile	Length m	6.00			6.00					6.00			6.00			6.00			6.00		
	Stress N/mm^2	57 (<165)	37 (<190)		42 (<165)	26 (<190)				42 (<165)	26 (<190)		17 (<165)	13 (<190)		57 (<165)	37 (<190)		27 (<165)	25 (<190)	
	Penetration m	5.70			5.70					5.70			5.70			5.70			5.70		
	depth	(>5.43)	(>5.43)		(>5.43)	(>5.43)				(>5.43)	(>5.43)		(>5.43)	(>5.43)		(>5.43)	(>5.43)		(>5.43)	(>5.43)	
	Horizontal mm displacement	8.11 (<50.00)	5.27 (<75.00)		5.93 (<50.00)	3.65 (<75.00)				5.93 (<50.00)	3.67 (<75.00)		2.43 (<50.00)	1.80 (<75.00)		8.11 (<50.00)	5.27 (<75.00)		3.86 (<50.00)	3.52 (<75.00)	
Tie-Rod	Diameter φ mm	Φ46			Φ42					Φ42			Φ25			Φ46			Φ32		
	Pitch @ m	@2.40			@2.40					@2.40			@2.40			@2.40			@2.40		
	Stress N/mm^2	170 (<176)	111 (<264)		150 (<176)	92 (<264)				150 (<176)	92 (<264)		173 (<176)	128 (<264)		170 (<176)	111 (<264)		168 (<176)	153 (<264)	
Wale	Specification	2×UPN-220×80			2×UPN-200×75					2×UPN-200×75			2×UPN-180×70			2×UPN-220×80			2×UPN-180×70		
	Stress N/mm^2	139 (<140)	90 (<210)		130 (<140)	80 (<210)				130 (<140)	80 (<210)		68 (<140)	50 (<210)		139 (<140)	90 (<210)		108 (<140)	98 (<210)	
Location of bracing	m	11.00			11.00					11.00			6.50			10.00			6.50		
sheet pile		(>7.33)	(>8.63)		(>7.04)	(>8.36)				(>7.04)	(>8.35)		(>5.59)	(>6.43)		(>7.33)	(>8.63)		(>5.88)	(>6.45)	

Table13-2.4 Result of the consideration for bank protection works (2/3)

Regulator Name		New Ibrahimia Regulator																	
Type		D-1			D-2		E-1			E-2		F			G-1			G-2	
Construction Length		3.60m			5.40m		3.00m			1.80m		72.60m			6.60m			6.00m	
Sheet Pile Type		Tie-Rod			Free-standing cantilever		Tie-Rod			Free-standing cantilever		Tie-Rod			Tie-Rod			Free-standing cantilever	
		Long time	Sort time (Seismic)	During construction (H=4.50m)	Long time	Sort time (Seismic)	Long time	Sort time (Seismic)	During construction (H=4.50m)	Long time	Sort time (Seismic)	Long time	Sort time (Seismic)	During construction (H=3.50m)	Long time	Sort time (Seismic)	During construction (H=3.50m)	Long time	Sort time (Seismic)
Front sheet pile	Model	PU18			PU12		PU12			PU12		PU18			PU12			PU12	
	Length m	16.00			9.50		13.50			8.00		17.50			15.00			9.50	
	Stress N/mm^2	157 (<165)	86 (<190)	79 (<165)	106 (<165)	99 (<190)	135 (<165)	74 (<190)	38 (<165)	31 (<165)	34 (<190)	157 (<165)	86 (<190)	43 (<165)	135 (<165)	75 (<190)	62 (<165)	88 (<165)	78 (<190)
	Penetration m	8.70			6.70		7.50			6.50		10.20			9.00			7.00	
	depth	(>8.55)	(>1.96)	(>7.44)	(>6.39)	(>6.59)	(>7.44)	(>1.25)	(>6.31)	(>6.06)	(>6.33)	(>9.90)	(>5.85)	(>6.71)	(>8.92)	(>4.97)	(>5.89)	(>6.17)	(>6.31)
	Horizontal mm displacement			36.67 (<50.00)	48.11 (<50.00)	46.60 (<75.00)			12.26 (<50.00)	9.57 (<50.00)	10.92 (<75.00)			33.22 (<50.00)			43.37 (<50.00)	36.83 (<50.00)	33.51 (<75.00)
Bracing sheet pile	Model	PU12					PU12					PU12			PU12				
	Length m	6.00					6.00					6.00			6.00				
	Stress N/mm^2	57 (<165)	37 (<190)				42 (<165)	28 (<190)				57 (<165)	37 (<190)		42 (<165)	28 (<190)			
	Penetration m	5.70					5.70					5.70			5.70				
	depth	(>5.43)	(>5.43)				(>5.43)	(>5.43)				(>5.43)	(>5.43)		(>5.43)	(>5.43)			
	Horizontal mm displacement	8.11 (<50.00)	5.27 (<75.00)				5.97 (<50.00)	3.93 (<75.00)				8.11 (<50.00)	5.27 (<75.00)		5.97 (<50.00)	3.99 (<75.00)			
Tie-Rod	Diameter φ mm	Φ46					Φ42					Φ46			Φ42				
	Pitch @ m	@2.40					@2.40					@2.40			@2.40				
	Stress N/mm^2	170 (<176)	111 (<264)				150 (<176)	99 (<264)				170 (<176)	111 (<264)		150 (<176)	101 (<264)			
Wale	Specification	2×UPN-220×80					2×UPN-200×75					2×UPN-220×80			2×UPN-200×75				
	Stress N/mm^2	139 (<140)	90 (<210)				131 (<140)	86 (<210)				139 (<140)	90 (<210)		131 (<140)	88 (<210)			
Location of bracing m		9.00					8.00					10.50			9.00				
sheet pile		(>7.33)	(>8.63)				(>6.57)	(>7.60)				(>7.33)	(>8.63)		(>6.57)	(>7.65)			

Table13-2.5 Result of the consideration for bank protection works (3/3)

Regulator Name			New Sahelyia Regulator			New Badraman Regulator (Diroutiah)				New Badraman Regulator (Badraman)				New Abo Gabal Regulator		
Type			H			I		J		K		L		M		
Construction Length			19.20m			6.60m		4.20m		6.60m		3.60m		45.00m		
Sheet Pile Type			Tie-Rod			Free-standing cantilever		Free-standing cantilever		Free-standing cantilever		Free-standing cantilever		Tie-Rod		
			Long time	Sort time (Seismic)	During construction (H=3.50m)	Long time	Sort time (Seismic)	Long time	Sort time (Seismic)	Long time	Sort time (Seismic)	Long time	Sort time (Seismic)	Long time	Sort time (Seismic)	During construction (H=3.40m)
Front sheet pile	Model		PU12			PU12		PU12		PU18		PU12		PU12		
	Length	m	11.00			9.00		8.00		10.00		8.00		9.50		
	Stress	N/mm^2	93 (<165)	52 (<190)	49 (<165)	104 (<165)	71 (<190)	45 (<165)	28 (<190)	87 (<165)	59 (<190)	58 (<165)	36 (<190)	49 (<165)	28 (<190)	46 (<165)
	Penetration	m	5.75			5.50		5.60		6.20		5.30		5.30		
	depth		(>5.29)	(>1.58)	(>5.36)	(>5.21)	(>5.21)	(>5.21)	(>5.21)	(>6.06)	(>6.06)	(>5.25)	(>5.25)	(>1.39)	(>0.86)	(>5.23)
	Horizontal displacement	mm			31.29 (<50.00)	39.00 (<50.00)	26.84 (<75.00)	12.81 (<50.00)	7.93 (<75.00)	35.12 (<50.00)	23.83 (<75.00)	18.13 (<50.00)	11.16 (<75.00)			23.16 (<50.00)
Bracing sheet pile	Model		PU12											PU12		
	Length	m	6.00											6.00		
	Stress	N/mm^2	35 (<165)	24 (<190)										25 (<165)	18 (<190)	
	Penetration	m	5.70											5.70		
	depth		(>5.43)	(>5.43)										(>5.43)	(>5.43)	
	Horizontal displacement	mm	4.90 (<50.00)	3.34 (<75.00)										3.60 (<50.00)	2.51 (<75.00)	
Tie-Rod	Diameter φ	mm	Φ42											Φ32		
	Pitch @	m	@2.40											@2.40		
	Stress	N/mm^2	151 (<176)	103 (<264)										156 (<176)	109 (<264)	
Wale	Specification		2×UPN-180×70											2×UPN-160×65		
	Stress	N/mm^2	137 (<140)	93 (<210)										130 (<140)	91 (<210)	
Location of bracing sheet pile		m	7.50											6.50		
			(>6.14)	(>7.08)										(>5.54)	(>6.29)	

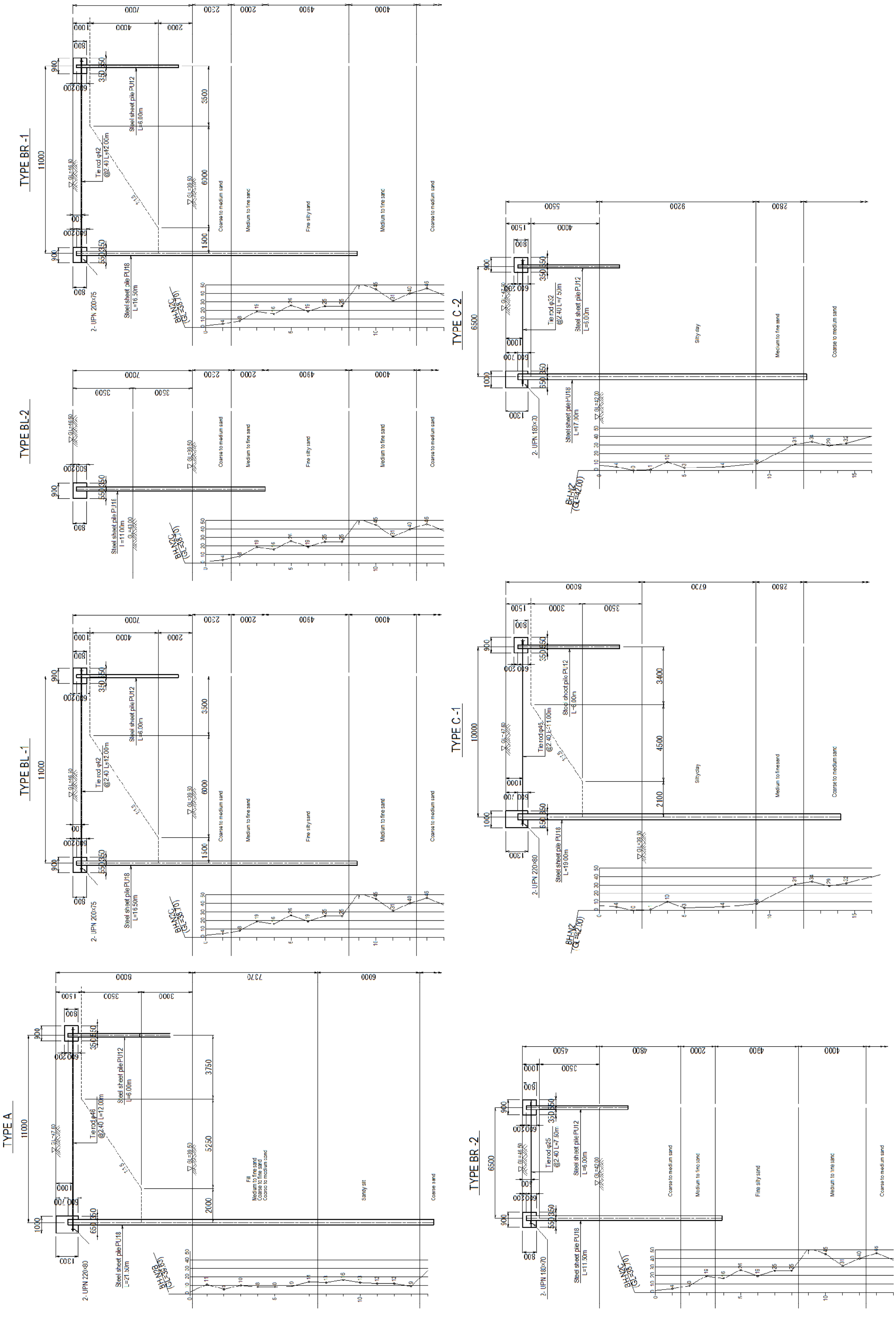


Figure13-2.3 Cross-sectional map of the sheet pile method for each case (case A – C) (1/3)

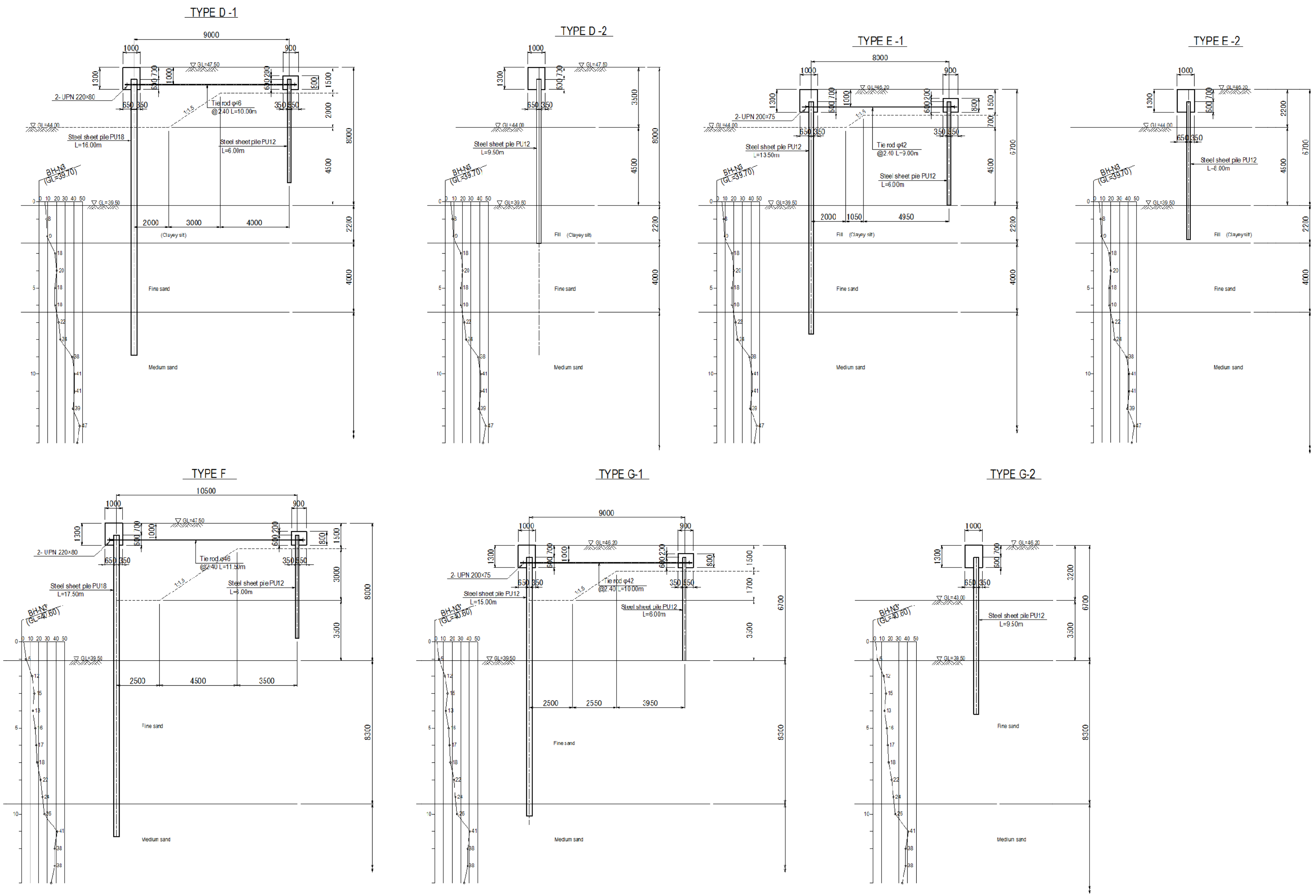


Figure13-2.4 Cross-sectional map of the sheet pile method for each case (case D – G) (2/3)

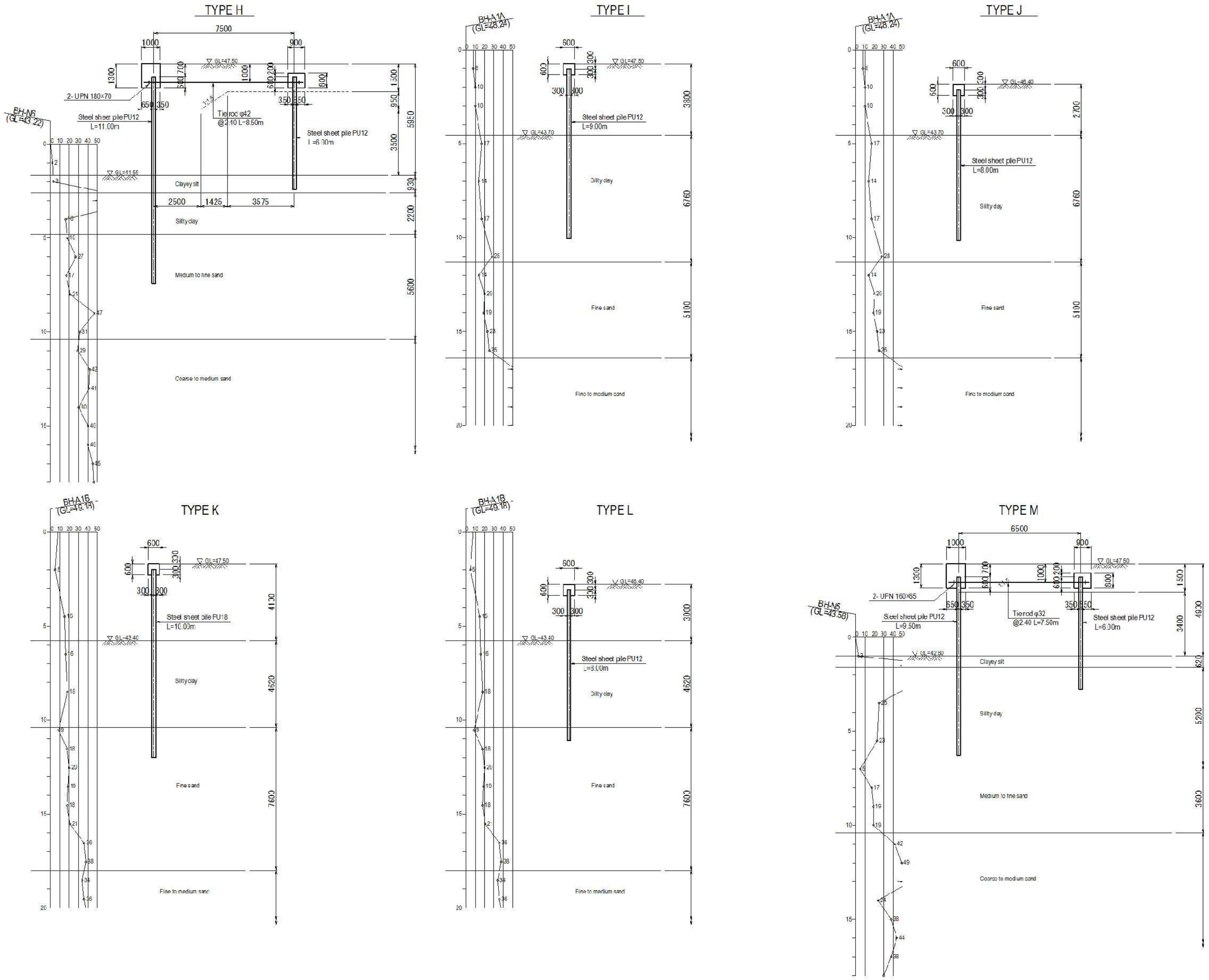


Figure13-2.5 Cross-sectional map of the sheet pile method for each case (case H – M) (3/3)

13-3 Design of bank slope protection work

(1) Wet stone pitching

Wet stone pitching is used, which was also used in the construction of the Dahab regulator. A drainage hole and backfill material are employed to drop the residual water level. Stone for the protection work should be heavy enough so as not to be displaced naturally, and also to satisfy the value calculated by Hudson Formula below.

$$W = \frac{\gamma r \cdot H_D^3}{K_D(\gamma r / w_0 - 1)^3 \cot \alpha}$$

Where, W : Weight of the stone on the slope (kN)

γr : Unit weight of the stone $\gamma r = 26$ kN/m^3

w_0 : Unit weight of the water$W_0 = 10$ kN/m^3

α : Angle comprised by the slope and horizontal lines $\alpha = 33°\ 41'$ (1 : 1.5)

K_D : Constant determined by the stone type ($K_D = 2$ is applied in the study)

H_D : Wave height on the front of slope ($H_D = 0.50$ m is applied in the study)

$\therefore$ W = 0.264 kN

Thus, the weight of stone for pitching should be W=0.30kN (rounded to safe side), which is around 30cm in average diameter.

The standard cross-sectional map is shown below.

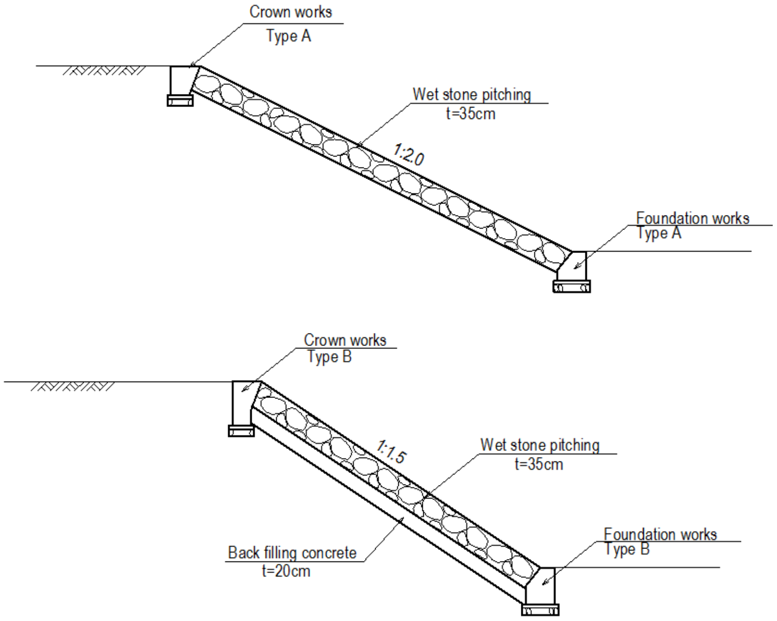


Figure 13-3.1 Standard cross-sectional map of wet stone pitching works

(2) Gabion

The flow channel shaping works are carried out for the purpose of preventing the vortexes generated in the dead water areas on the downstream left bank of the Bahr Yusef Regulator and on the downstream right bank of the Ibrahimia Regulator. The resulting embankment and bank protection works are done apart from the tentative cofferdam works to be executed in the main work. The runoff prevention measure is one of the construction conditions for the works.

Based on these, the comparative analyses were made among the steel sheet pile method, the wet stone pitching method and the gabion construction method (stacking type or pitching type). (Table 13-3.1 and 13-3.2.) As the result of repeated discussions with the Design WG, the pitching type (with the slope gradient 1:2.0) gabion construction method was decided on the prerequisite that the construction works should be done under the low water level condition during the winter closure period, and approved in the 25th TAC Meeting.

The standard cross-sectional map of the gabion construction method and the results of slope stability calculations (Fs = 1.648 > Fa = 1.5) are shown below.

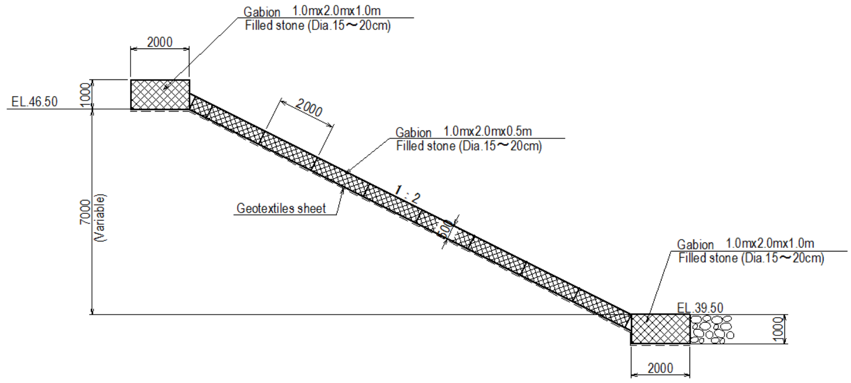


Figure 13-3.2 Standard sectional map of gabion construction method

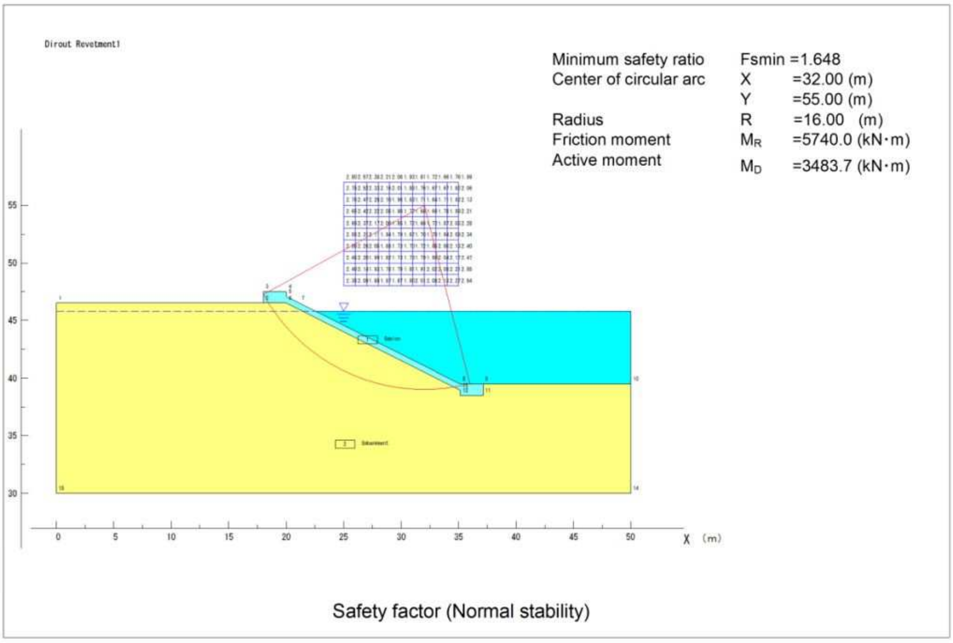


Figure 13-3.3 Diagram of stability calculation results of gabion construction method

Table 13-3.1 Comparative analyses of downstream revetment works (1/2)

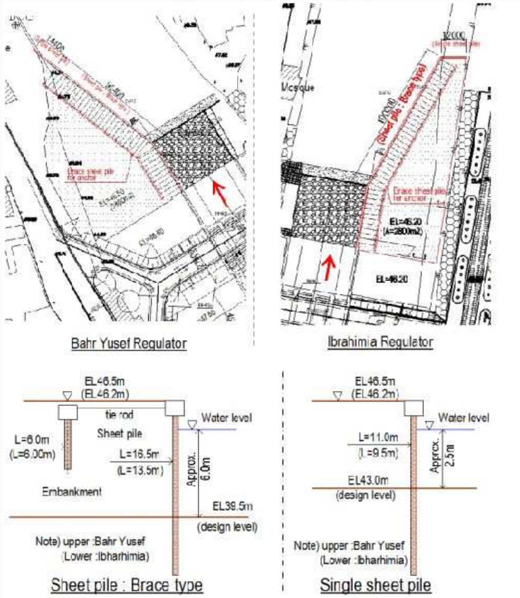
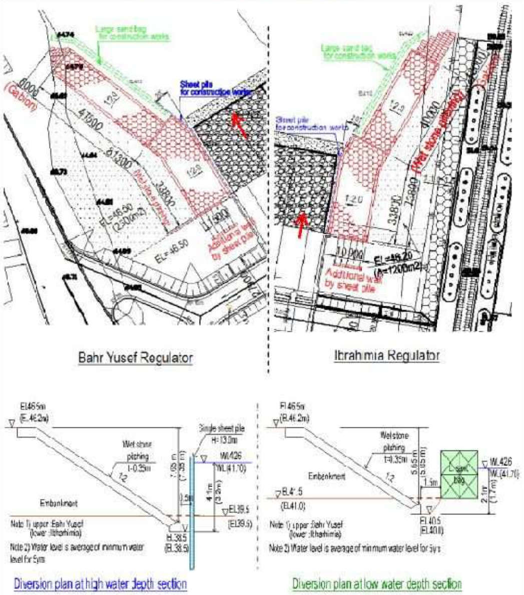
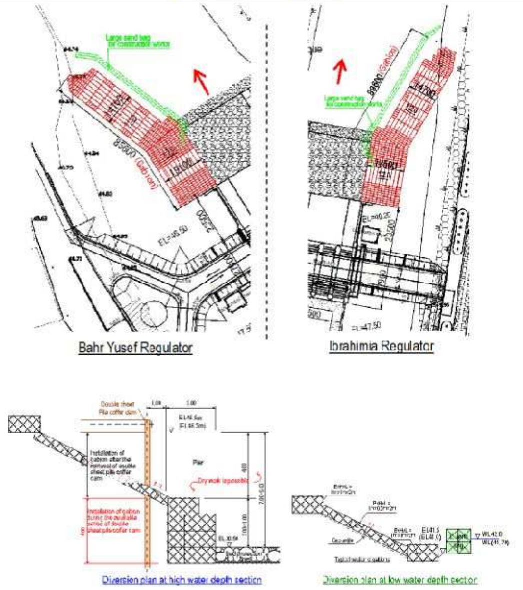
Items	Plan A : Steel sheet type	Plan B : Wet stone pitching type	Plan C : Gabion walls
Plan	 Bahr Yusef Regulator Ibrahimia Regulator EL46.5m (EL46.2m) tie rod Sheet pile Water level L=6.0m (L=6.00m) L=16.5m (L=13.5m) Approx. 6.0m Embankment EL39.5m (design level) Note) upper :Bahr Yusef (Lower :Ibharhimia) Sheet pile : Brace type L=11.0m (L=9.5m) Approx. 2.5m EL43.0m (design level) Single sheet pile	 Sheet pile for construction works Large sand bag for construction works Additional wall by sheet pile Bahr Yusef Regulator Ibrahimia Regulator EL46.5m (EL46.2m) Wet stone pitching t=0.35m 1:2 Single sheet pile H=13.0m WL42.6 WL(41.70) Embankment EL39.5 (EL39.5) EL38.5 (EL38.5) Note 1) upper :Bahr Yusef (lower :Ibrahimia) Note 2) Water level is average of minimum water level for 5yrs Diversion plan at high water depth section EL41.5 (EL41.0) 1.5m Large sand bag EL40.5 (EL40.0) Diversion plan at low water depth section	 Large sand bag for construction works Bahr Yusef Regulator Ibrahimia Regulator Double sheet Pile coffer dam Installation of gabion after the removal of double sheet pile coffer dam Pier Drywork impossible Installation of gabion during the available period of double sheet pile coffer dam Diversion plan at high water depth section Geotextile Diversion plan at low water depth section
1. Hydraulic aspect	- The bank shape is most smooth among three plans because the alignment of sheet pile make the shape smooth without gaps between regulator and sheet pile wall. - The hydraulic roughness on the wall surface is the smallest among three plans **(Good)**	- The bank shape is fairly smooth but there are gaps between the alignment of regulator and stone pitching wall. - The hydraulic roughness on the wall surface is larger than "Plan A". **(Moderate)**	- The bank shape is fairly smooth but there are gaps between the alignment of regulator and gabion wall. - The hydraulic roughness on the wall surface is larger than "Plan A" **(Moderate)**
2. Structural aspect	- The strength is enough as the retaining wall, - The anti-corrosion painting is required on the surface of sheet pile. - The brace sheet piles are necessary to enhance main sheet pile to resist the high stress by water and earth soil. **(Good)**	- The strength is enough as the retaining wall - Any corrosion is not concerned. - To make the boundary between the regulator and wet stone pitching, the additional walls by sheet pile wall of brace type are required. These are 11.5m for Bahr Yusef and 10.9m for Ibrahimia. **(Good)**	- The strength is moderate as the retaining wall, but flexible structure can follow and protect the vulnerable canal bank and bed. - The galvanized flame such as anti-corrosion measure should be applied. **(Good)**
3. Ease of construction	-The construction works is as following steps 1) Spread of the soil to the target area until the workable level of the sheet driving 2) Driving the sheet pile along the alignment and, set the anchor and tie rod 3) Compaction of the soil - Since the sheet pile walls is available as the coffer dam, the works are not affected by the canal water. - However, the construction works is complicated among three plans. - In addition, in the Ibrahimia regulators, the harmful effect to the railway would be concerned when the sheet piles are driven close	-The construction works is as following steps 1) Spread of the soil to the target area until the design embankment level. 2) Driving the sheet piles and setting the large sand bags along the alignment of bank as the diversion works 3) Construction of the wet stone pitching during the winter closure 4) Removal of the sheet pile and the large sand bags, but removal of sheet pile is so difficult after the construction of wet stone pitching - The structure type is not difficult, but the construction yard enable the dry works must be secured for the concrete works. - Considering the reasonable diversion works to secure the necessary construction yard, the works must be done during winter	-The construction works is as following steps 1) Firstly, during the available periods of double sheet pile coffer dam, the gabions at the close area to the regulator are constructed in advance. The way of gabion installation is shown in the above illustration. 2) After the removal of the double sheet pile coffer dam, the other area of gabions are constructed with utilization of the large sand bag coffer dam to secure the construction yard. - To avoid heavy diversion works, the construction works are divided by two terms. - Therefore the diversion works such as sheet pile is not required. - In addition, the works of gabions are available unless its water

Table 13-3.2 Comparative analyses of downstream revetment works (2/2)

Items	Plan A : Steel sheet type	Plan B : Wet stone pitching type	Plan C : Gabion walls
	the railway **(Not Good)**	closure. - However, the gap between the base concrete level and canal water level will be approx. 4~3m near the regulator. Therefore, the sheet pile diversion should be applied in order to resist high water pressure. Its water level is identified in the record of water level for 5yrs during winter closure. - While, the other area does not need the sheet pile diversion, but the sandbag diversion is available. **(Moderate)**	depth is not so deep. - Compared to the wet stone pitching, the construction period is short. **(Good)**
4. construction periods	Construction periods without embankment and concrete cap on sheet pile Bahr Yusef : approx. **0.8 month (approx. 95m)** Ibrahimia : approx. **0.8 month (approx. 100m)** **(Good)**	Construction periods without embankment Bahr Yusef : approx. **1.7 month (approx. 1,500m^2)** Ibrahimia : approx. **1.5 month (approx. 1,400m^2)** **(Not good)**	Construction periods without embankment Bahr Yusef : **0.4 month (approx. 600nos)** Ibrahimia : **0.6 month (approx. 790nos)** **(Good)**
5. Economical aspect	**Ratio : 1.69** **(Total : USD 1.0 million)** Items 1) Sheet pile and other works 2) Embankment works include transportation 3) Diversion works for the construction **(Not good : Expensive)**	**Ration : 1.05** **(Total : USD 0.63 million)** Items 1) wet stone pitching and other works 2) Embankment works include transportation 3) Diversion works for the construction **(Good)**	**Ration : 1.00** **(Total : USD 0.60 million)** Items 1) Gabions include stone and other works 2) Embankment works include transportation 3) Diversion works for the construction **(Very Good)**
Evaluation	**Fairly Recommendable** - The hydraulic function is very good and the structural durability is as well. - However, the careful construction works is required because of the complicated structure and necessity of careful driving sheet pile close the railway. - The construction cost is **most expensive among three plans**.	**Fairly Recommendable** -.The hydraulic function is good and structural durability is enough for conditions, in addition, structure is typical as bank protection. - However, under the condition of canal water during the construction, **the expensive diversion works such as sheet pile cofferdam is required** in order to prevent the canal water. - In addition, construction period is longer than other plans, its period **overrun for the available construction period of winter closure**.	**Recommendable** - The hydraulic function is good, and structural durability is fairly enough for corrosion, but flexible structure enable to follow and protect the vulnerable canal bank and bed. - The construction works are most speedy among three plans and its **works is possible to finish during winter closure.** - In addition, the construction works are **available by simple diversion works** such as sand bags. - The construction cost is **not expensive** compared to the other plan.

14. Design of Ancillary Road and Bridge

14-1 Design conditions

(1) Width of the ancillary road

Based on the discussion conclusions at the F/S stage, the effective width of ancillary road was designed at. However, in D/D stage, TAC decided at the14th TAC meeting, that the road plan should take future traffic into account. The road width at the three downstream regulators (new Bahr Yusef, Badraman, and Ibrahimia) should also consider the future increase in traffic in Dirout city.

According to the traffic survey study report, the required road width is approximately 25m. Based on this result, TAC and D/D consultant have agreed to apply 12.5m width (half of required road width) for the design, and the remaining 12.5m will be covered by the new bridges being planned as part of the city development plan. Regarding the two upstream small scale regulators (new Sahelyia and Abo Gabal), the width of the road was set at 6.5m to include maintenance usage.

The following is the breakdown of road for each width:

12.5m = 10.0m (for 2 carriage ways) + 2.0m (for 2 sidewalks) + 0.5m (for 2 handrails)

6.5m =6.0m (for carriage way) + 0.5m (for 2 handrail)

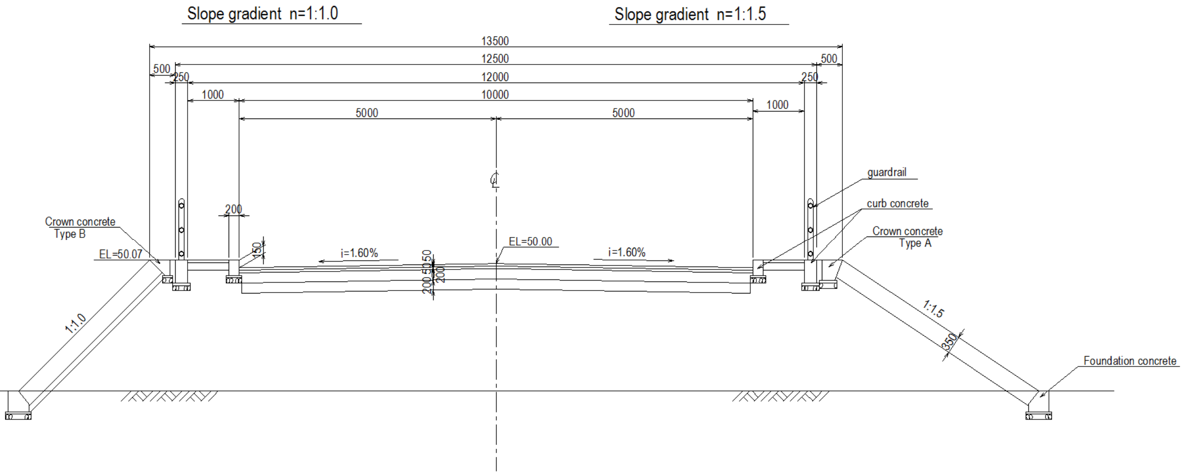


Figure14-1.1 Layout of ancillary road

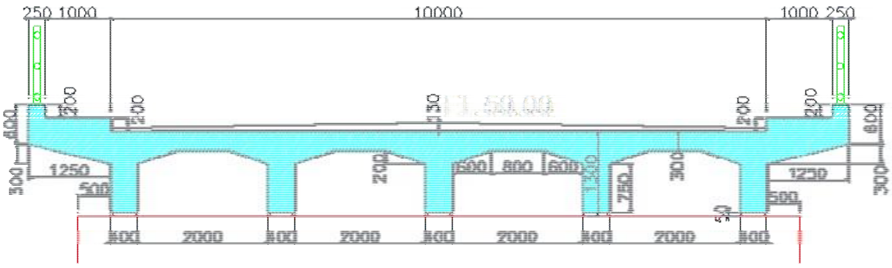


Figure14-1.2 Layout of bridge

(2) Design load

In order to determine the design load for the ancillary road and bridge, the following loads should be applied in order to comply with Egyptian code.

Table14-1.1 Design load for the ancillary road and bridge

Point where the load acts	Concentrated lad (by the car) Q (kN)	Equal distribution load q (kN/m^2)
Lane ①	300	9.0
Lane ②	200	2.5
Lane ③	100	2.5
The other lane	0	2.5
The other area (q)	0	2.5

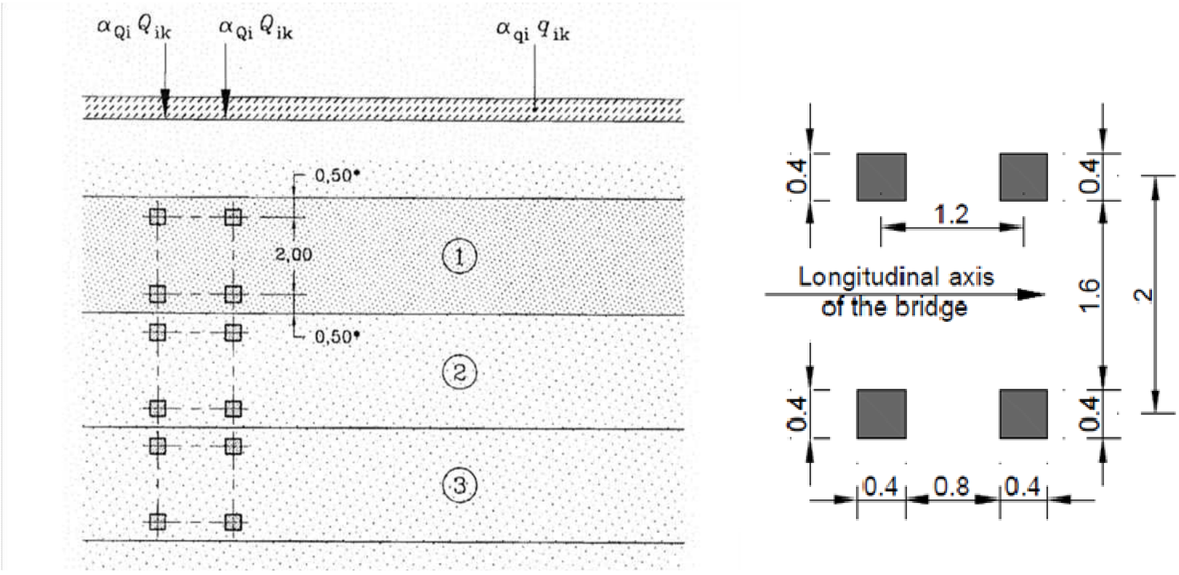


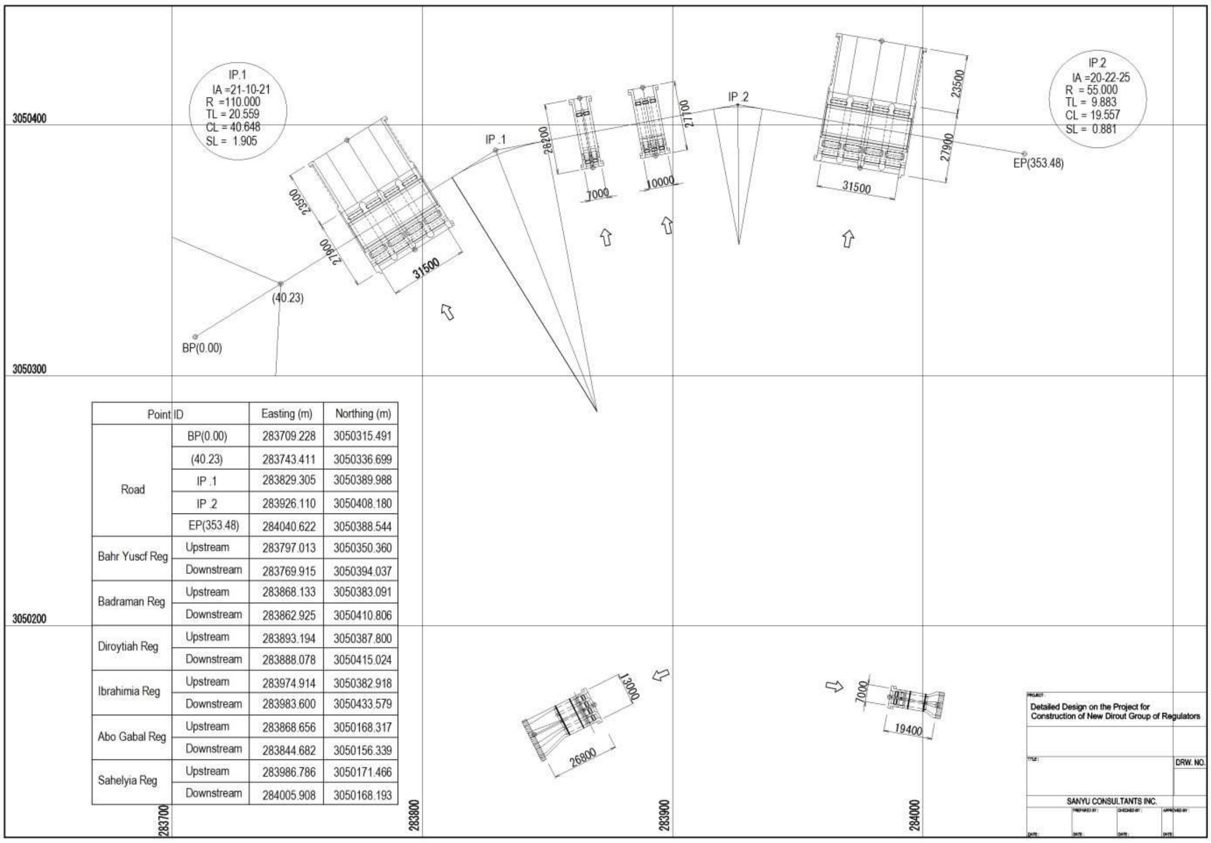
Figure14-1.3 Sketch of acting point of the design load

(3) Road alignment

Figure 14-1.4 shows the location of NDGRs and their ancillary roads.

The following two points were approved by TAC at the21st TAC meeting.

- Considering the heavy traffic on the existing national road along the Bahr Yusef canal, a traffic island will be constructed at the intersection between the road on the new Bahr Yusef regulator and the existing national road to avoid traffic jams.
- The design area of the study is until the slope for the railway, which is located along the right bank of Ibrahimia canal.



Point ID		Easting (m)	Northing (m)
Road	BP(0.00)	283709.228	3050315.491
	(40.23)	283743.411	3050336.699
	IP .1	283829.305	3050389.988
	IP .2	283926.110	3050408.180
	EP(353.48)	284040.622	3050388.544
Bahr Yuscf Reg	Upstream	283797.013	3050350.360
	Downstream	283769.915	3050394.037
Badraman Reg	Upstream	283868.133	3050383.091
	Downstream	283862.925	3050410.806
Diroytiah Reg	Upstream	283893.194	3050387.800
	Downstream	283888.078	3050415.024
Ibrahimia Reg	Upstream	283974.914	3050382.918
	Downstream	283983.600	3050433.579
Abo Gabal Reg	Upstream	283868.656	3050168.317
	Downstream	283844.682	3050156.339
Sahelyia Reg	Upstream	283986.786	3050171.466
	Downstream	284005.908	3050168.193

Figure 14-1.4 Drawing of the design road alignment

14-2 Structural design for the ancillary bridge

The structural design of the ancillary bridge was basically made in accordance with the Egyptian code, and the items that were not provided in the Egyptian code were in accordance with the Eurocode or AASHTO.

The calculations of cross sections were made for three bridges for the large-scale regulators (Bahr Yusef and Ibrahimia regulators), Badraman regulator (Diroutiah canal) and Badraman regulator (Badraman canal). The calculated cross sections are shown in Figure 14-2.1.

Further details are in structural calculations in the Appendix.

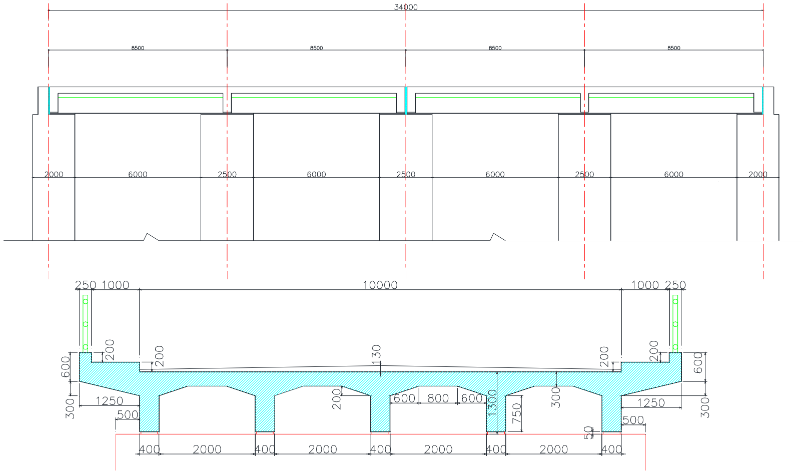
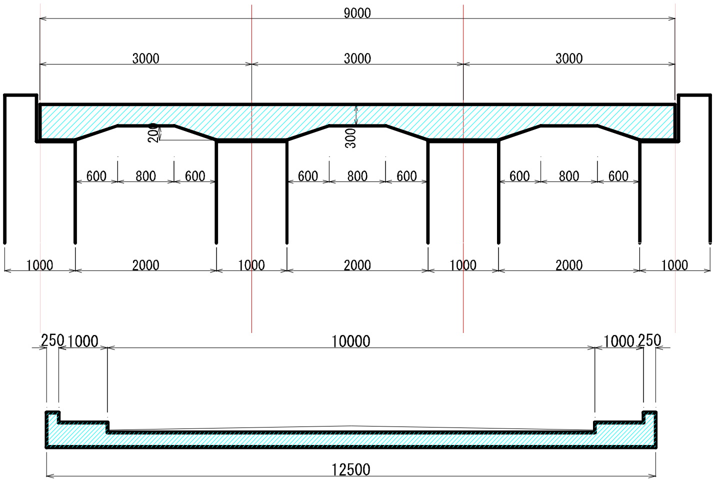
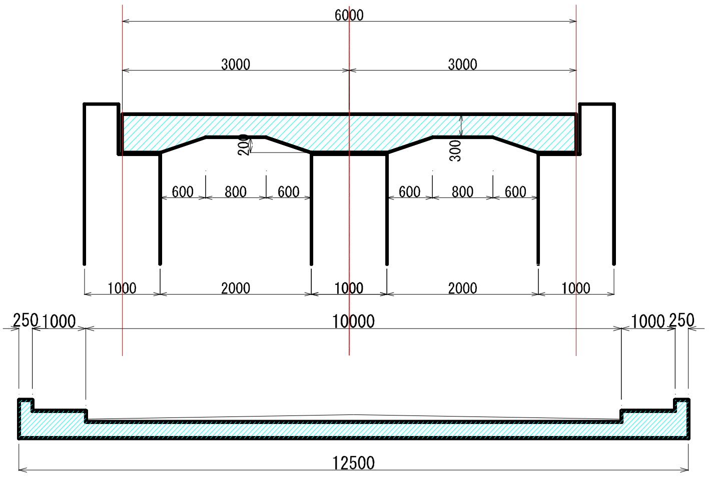
Name of Bridge	General Diagram of Bridge Type and Structure
Large-scale regulators Bahr Yusef regulator Ibrahimia regulator	Bridge type: RC 2-span continuous 5-slab main girder bridge × 2 bridges  34000 8500 8500 8500 8500 2000 6000 2500 6000 2500 6000 2500 6000 2000 250 1000 10000 1000 250 600 300 200 200 130 200 200 600 300 1250 500 200 600 800 600 1300 750 300 1250 500 50 400 2000 400 2000 400 2000 400 2000 400
Badraman regulator Diroutiah canal	Bridge type: RC 3-span continuous floor slab bridge  9000 3000 3000 3000 200 300 600 800 600 600 800 600 600 800 600 1000 2000 1000 2000 1000 2000 1000 250 1000 10000 1000 250 12500
Badraman regulator Badraman canal	Bridge type: RC 2-span continuous floor slab bridge  6000 3000 3000 200 300 600 800 600 600 800 600 1000 2000 1000 2000 1000 250 1000 10000 1000 250 12500

Figure 14-2.1 Schematic diagrams of ancillary bridges

15. Design of Gate Facilities

Gate facilities shall be designed in accordance with the following features.

1) Easy and reliable operation
2) Sufficient water tightness and high durability
3) Safety against predictable load
4) Easy and safe operation and maintenance

15-1 Design of gate leaf

15-1-1 Design conditions

The following table shows the design conditions of gate facilities agreed upon with the Egyptian government. Items to be noted are as follows.

1) The operating speed of the gate is usually taken to be 0.3 m/min, as it considers the effect of upstream and downstream water level fluctuations caused by water discharge. However, sometimes higher speed is applied when sudden closing is required, and slower speed is applied for highly accurate discharge control. As a result of discussions, operating speed is set at 0.3 m/min for all gate facilities.

2) The major parts of the gate leaf are made of rolled steel, except the parts where maintenance and repair works are difficult, as well as the sliding surfaces such as the skin plate of the double leaf gate, the wheels, and the gate guide frames.

3) Beside the lateral and bottom side seal, a rubber seal is attached to the upper side of the lower leaf of the double leaf gate to secure water-tightness at the sliding surface.

4) Design water level is the same as the gate crest height (=Normal water level EL46.30m＋Freeboard 25cm). Downstream water height is not considered in the design for safety reasons.

Table 15-1.1 Design condition of gate facilities

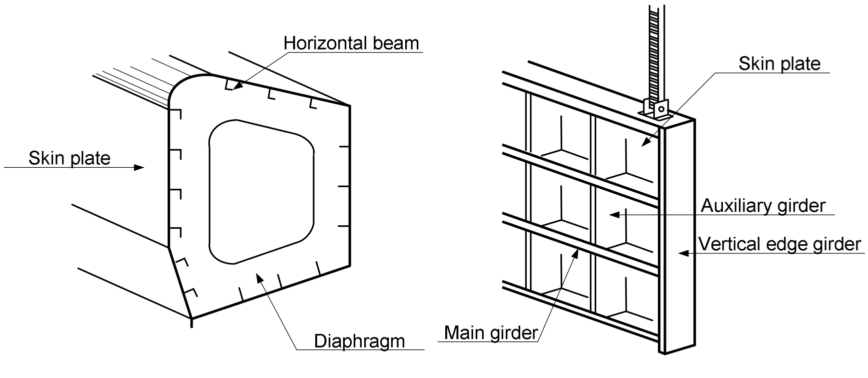
		Large regulators		Small regulators				Remarks
Name		**Bahr Yusef**	**Ibrahimia**	**Badraman**	**Diroutiah**	**AboGabal**	**Sahelyia**	
Gate type		Double leaf Fixed wheel gate	Double leaf Fixed wheel gate	Single leaf Slide gate	Single leaf Slide gate	Single leaf Slide gate	Single leaf Slide gate	
Clear width of opening		6.00m	6.00m	2.00m	2.00m	2.00m	2.00m	
Total height		6.55m	6.55m	2.65m	2.35m	2.95m	3.55m	
Number of gate		4	4	2	3	4	2	
Gate crest elavation		EL46.55m	EL46.55m	EL46.55m	EL46.55m	EL46.55m	EL46.55m	Freeboard=0.25m
Gate sill elevation		EL40.00m	EL40.00m	EL43.90m	EL44.20m	EL43.60m	EL43.00m	
Design water level(Upstream)		EL46.55m	EL46.55m	EL46.55m	EL46.55m	EL46.55m	EL46.55m	
Design water height		6.55m	6.55m	2.65m	2.35m	2.95m	3.55m	
Bottom height when lifted up		EL47.50m	EL47.50m	EL47.50m	EL47.50m	EL47.50m	EL47.50m	HHWL+0.5m
Lifting height		7.50m	7.50m	3.60m	3.30m	3.90m	4.50m	
Operating speed		0.3m/min	0.3m/min	0.3m/min	0.3m/min	0.3m/min	0.3m/min	
Control method		Remote/Local control	Remote/Local control	Remote/Local control	Remote/Local control	Remote/Local control	Remote/Local control	
Hoist type (Number of rod per gate)		Hydraulic cylinder	Hydraulic cylinder	Electric rack gear (2-rods)	Electric rack gear (2-rods)	Electric rack gear (2-rods)	Electric rack gear (2-rods)	
Seal type		3-side rubber seal 1)	3-side rubber seal 1)	3-side rubber seal	3-side rubber seal	3-side rubber seal	3-side rubber seal	
Materials	Skin plate	Stainless steel	Stainless steel	Rolled steel	Rolled steel	Rolled steel	Rolled steel	
	Main beam	Rolled steel	Rolled steel	Rolled steel	Rolled steel	Rolled steel	Rolled steel	
	Wheels	Stainless steel	Stainless steel	-	-	-	-	
	Gate guide frame	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	
	Bolt,Nut &Washer	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	
	Hydraulic pipe	Stainless steel	Stainless steel	-	-	-	-	
Deflection		1/800	1/800	1/800	1/800	1/800	1/800	
Allowable stress		According to JIS (Japanese Industrial Srandards) or relevant standards						

Note: 1) Lower leaf has a upper side seal. (4-side seal)

15-1-2 Gate leaf structure

The gate leaf structure can be a ‘shell’ type or a ‘plate girder’ type. Which type is selected is determined by the width and height of the leaf or the control method; whether to discharge by overflow or not. With the girder type, the depth of the main girder supporting the horizontal load becomes large depending on the span width. Since higher vertical rigidity is required to keep the deflection caused by self-weight within the allowable range, the design of the structure becomes uneconomical. On the other hand, each cross-sectional part of the shell type leaf can function well structurally and its shape is hydraulically desirable.

For these reasons, the ratio between height and width of the gate leaf is an index to select the structural type. Shell type is adopted when the ratio is less than 1/5 to 1/6, otherwise the girder type is selected.



Shell type structure

Plate girder structure

Figure 15-1.1 Structure of gate leaf

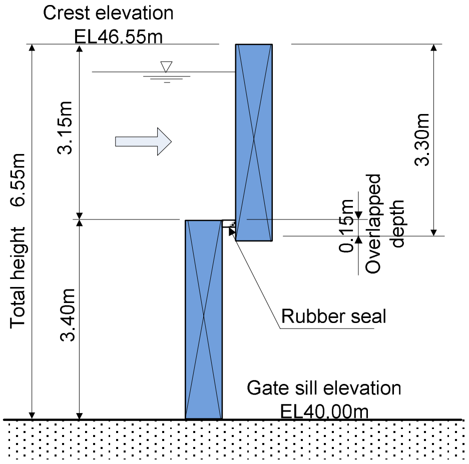
The ratio of the leaves of large scale regulators is as follows.

Upper leaf: H/L＝3.30m/6.0m＝1/1.82

Lower leaf: H/L＝3.40m/6.0m＝1/1.76

Therefore the plate girder type is suitable for both upper and lower leaf structures. For the same reason, all the small scale regulators are plate girder type.

The height of the upper and lower leaves of double leaf gate was designed as shown in Figure 15-1.2. In order to avoid water from overflowing onto the lower leaf top, the upper leaf should be placed on the downstream side.



6.55m+0.15m(overlap）=6.70m
6.70m/2=3.35m→3.40m(Lower leaf),3.30m(Upper leaf)

Figure 15-1.2 Height of double leaf gate

15-1-3 Design load

In designing a gate, the following loads and their combinations shall be taken into account: weight of the gate, hydrostatic pressure, sediment pressure, wave pressure, buoyancy, hydrodynamic pressure caused by earthquake, effects of temperature changes, and so on.

(1) Hydrostatic pressure

Hydrostatic pressure of the reservoir water acts on the contact face of a hydraulic gate at a square. Hydrostatic pressure is determined from the following formula.

$P = W_o h_o$

Where, P: Hydrostatic pressure at a given point on the contact face (kN/m^2)
Wo: Weight of water per unit volume (kN/m^3)
ho: Head from water level just upstream of a gate plus wave height (m)

(2) Sediment pressure

The sediment pressure for the vertical force should be taken as the weight of the sedimentary silt in the water, and the horizontal force should be determined by the following formula.

$Pe = CeW_1 d$

Where Pe: Horizontal force of sediment pressure at a given point on the contact face (kN/m^2)
Ce: Sediment pressure factor (Ce=0.3-0.6)
W_1: Unit weight of sedimentary silt in water (kN/m^3)
d: Depth from deposit level of sediment to given point on contact face (m)

$W_1 = W - (1 - v)\, W_o$

Where, W_1: Apparent unit weight of sedimentary silt (kN/m^3)
v: Void ratio of sedimentary silt (0.30- 0.45)
W_o: Unit weight of water (kN/m^3)

(3) Wave height by wind

Where the upstream face of a weir is almost vertical, the wave height should be determined by the S.M.B (Sverdrup-Munk- Bretschneider) method.

$hw = 0.00086\, V^{1.1} F^{0.45}$

Where, hw: Total wave height (one third maximum wave) (m)
F: Distance to opposite bank (m)
V: Wind velocity (average of 10 minutes) (m/s)

(4) Wave height by earthquake

Wave height by earthquake is calculated by the following formula.

$$he = \frac{k \cdot \tau}{2\pi} \sqrt{g \cdot H}$$

Where, *h*e: Wave height (m)
k: Design seismic coefficient
τ : Frequency of the earth quake (s)
g: Acceleration of gravity (=9.8m/sec2)
H: Design depth of water in the river (m)

(5) Hydrodynamic pressure caused by earthquake

Hydrodynamic pressure caused by earthquake is obtained by Westergard's formula.

$$p_d = \frac{7}{8} Wok\sqrt{Hh}$$

Where, Pd：Dynamic water pressure (kN/m^2)

Wo: Unit weight of water (kN/m^3)

k: Design seismic coefficient

H: Design depth of water in the river (m)

h: Calculation depth (m)

15-1-4 Allowable stress

Allowable stresses of JIS materials for leaf, guide frame, and fixed part are given in tables below. However, allowable stresses for stoplogs for maintenance, and the setting frames are corrected by multiplying the following values by 1.5. Allowable stresses of standardized materials other than JIS, such as BS, DIN, or ASTM, are examined respectively.

Table 15-1.2 Allowable stress of structural steel

(Unit: N/mm^2)

Steel Stress	SS400,SM400,SMA400		SM490		SMA490	
	Thickness≤40mm	>40	Thickness≤40mm	>40	Thickness≤40mm	>40
1.Axial tensile stress (for net sectional area)	120	0.92 times the left stress	160	0.94 times the left stress	180	0.95 times the left stress
2.Axial compressive stress (for gross sectional area) Compressive member *l*: buckling length of member (mm) *r*: radius of gyration of area for the cross section of members (mm) Compressive splice plate	$\frac{l}{r} \leq 20$: 120 $20 < \frac{l}{r} \leq 93$: $120 - 0.75(\frac{l}{r} - 20)$ $93 < \frac{l}{r}: \frac{1{,}000{,}000}{6{,}700 + (\frac{l}{r})^2}$ 120		$\frac{l}{r} \leq 15$: 160 $15 < \frac{l}{r} \leq 80$: $160 - 1.12(\frac{l}{r} - 15)$ $80 < \frac{l}{r}: \frac{1{,}000{,}000}{5{,}000 + (\frac{l}{r})^2}$ 160		$\frac{l}{r} \leq 14$: 180 $14 < \frac{l}{r} \leq 76$: $180 - 1.33(\frac{l}{r} - 14)$ $76 < \frac{l}{r}: \frac{1{,}000{,}000}{4{,}500 + (\frac{l}{r})^2}$ 180	
3. Bending stress girder's tensile side (for net sectional area) girder's compressive side (for gross sectional area) Aw: gross sectional area of web plate (mm^2) Ac: gross sectional area of compressive flange (mm^2) *l*: distance between fixed points of compressive flange (mm) b: width of compressive flange (mm) $\mathrm{K} = \sqrt{3 + \frac{Aw}{2Ac}}$ When directly fixed to the skin plate etc.	120 $\frac{l}{b} \leq \frac{9}{K}$: 120 $\frac{9}{K} < \frac{l}{b} \leq 30$: $120 - 1.1(\mathrm{K}\frac{l}{b} - 9)$ But, say $\frac{Aw}{Ac} < 2, \mathrm{K} = 2$ with 120		160 $\frac{l}{b} \leq \frac{8}{K}$: 160 $\frac{8}{K} < \frac{l}{b} \leq 30$: $160 - 1.6(\mathrm{K}\frac{l}{b} - 8)$ But, say $\frac{Aw}{Ac} < 2, \mathrm{K} = 2$ with 160		180 $\frac{l}{b} \leq \frac{7}{K}$: 180 $\frac{7}{K} < \frac{l}{b} \leq 27$: $180 - 1.9(\mathrm{K}\frac{l}{b} - 7)$ But, say $\frac{Aw}{Ac} < 2, \mathrm{K} = 2$ with 180	
4. Shearing stress	70		90		105	
5. Bearing stress	180		240		270	

Table 15-1.3 Allowable stress of cast steel and carbon steel

(Unit: N/mm^2)

Type of steel \ Type		Axial tensile stress	Axial compressive stress	Bending stress	Shearing stress	Bearing stress
Cast steel	SC450	110	110	110	65	165
	SC480	120	120	120	70	180
	SCW410	120	120	120	70	180
Carbon steel for machine structural use	S20C	120	120	120	70	180
	S25C	130	130	130	75	195
	S35C	150	150	150	85	225
	S45C	170	170	170	95	255

Table 15-1.4 Allowable stress of joint steel

(Unit: N/mm^2)

Type \ Type of steel	SS400,SM400		SM490	
	Thickness≤40mm	>40	Thickness≤40mm	>40
Bolts	SS400,S20C		S35C	
1. Shearing stress Finishing bolts Anchor bolts	75 50	Same as at left	100 65	Same as at left
2. Bearing stress Finishing bolts	180	Multiply stress by 0.92 as mentioned on left	230	Multiply stress by 0.94 as mentioned on left

15-2 Design of hoisting equipment

15-2-1 Operating load

Operating load is calculated for a safe combination of the following factors.

1) Dead weight of movable parts of a leaf, 2) Friction at roller, 3) Friction of sealing rubber, 4) Friction by piled sand, 5) Floating load, 6) Vertical hydraulic forces, 7) Other.

The weight of hoisting shaft should be added to the dead weight of movable parts of a leaf as it is a load on the hoisting device. Once it is clear whether the gate can close by self-weight or not, the dead weight of leaf itself shall be considered.

15-2-2 Rack gear type hoist

Rack gear type hoist consists of rack shaft, stand (base frame), hoist, local control board and coupling of the shaft. Hoist is composed of power part, speed reducer, transmission, drive system, manual operation device, opening meter and protection devices, and it is standardized as a unit in Japan.

Strength design tests on the rack shaft are conducted for tensile stress, compressive stress, and buckling stress because tensile force acts on the shaft when opening, and compressive force works on it when closing.

In addition to the rack gear type, the spindle type whose leaf and hoist are connected by screw spindle is also popular for small scale gate facilities. When the small gate facilities are procured from the local market or countries other than Japan, the spindle type is applicable as long as equipment specifications are satisfied.

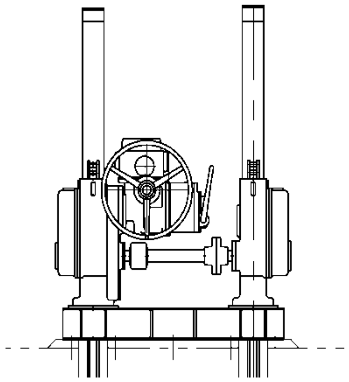


Figure 15-2.1 Rack gear type hoist

15-2-3 Hydraulic hoisting equipment

Hydraulic hoisting equipment consists of hydraulic cylinder, hydraulic unit, local control board, opening meter, protection device, and other maintenance instruments. The hydraulic unit is integrated with the hydraulic pump, electric motor, control valve, and oil tank. It generates hydraulic pressure to drive the hydraulic cylinders properly and control them.

(1) Number of hydraulic units

More than one gate facility can share the same hydraulic unit. It is necessary for gate facilities, which function as flood control or disaster prevention, to have one hydraulic unit per gate in case a single hydraulic unit causes more than one gate to malfunction at the same time. The Dirout Group of Regulators is movable weirs along irrigation canals. Their importance as a disaster prevention facility is not high, since water discharge is controlled by the Ibrahimia head regulators. The upstream spillway facility can also work in case of an emergency. As a result of discussions, it was decided to install one hydraulic unit for four gates of one regulator. In addition, to secure reliable gate operation, a duplexed hydraulic circuit including standby hydraulic pumps, shall be built inside the hydraulic unit, as well as a power generator situated beside a commercial power source.

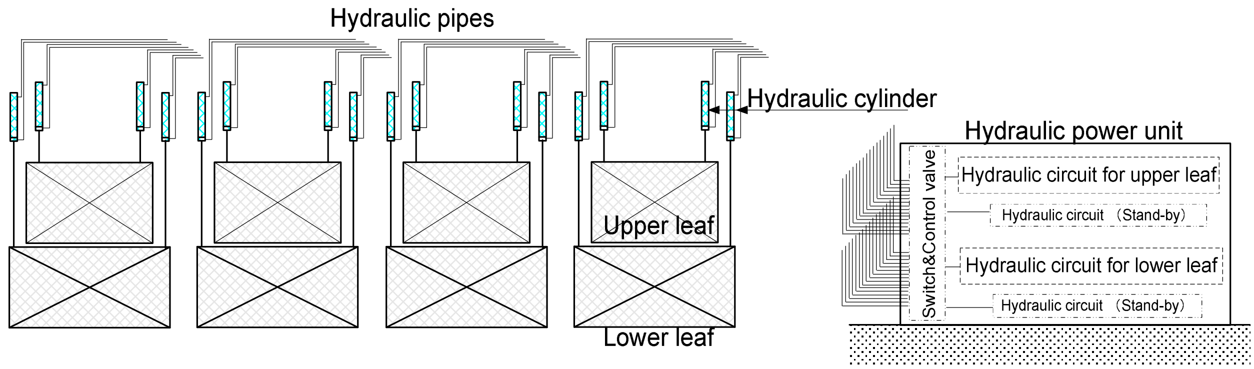

Hydraulic pipes
Hydraulic cylinder
Hydraulic power unit
Switch&Control valve
Hydraulic circuit for upper leaf
Hydraulic circuit （Stand-by）
Hydraulic circuit for lower leaf
Hydraulic circuit （Stand-by）
Upper leaf
Lower leaf

Figure 15-2.2 Layout of hydraulic unit

(2) Layout of hydraulic equipment

Three alternatives are examined for the layout of hydraulic equipment.

Plan A: Hydraulic unit is placed in the remote control room where monitoring and operations are carried out.

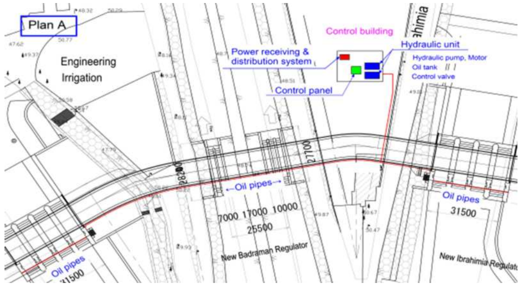
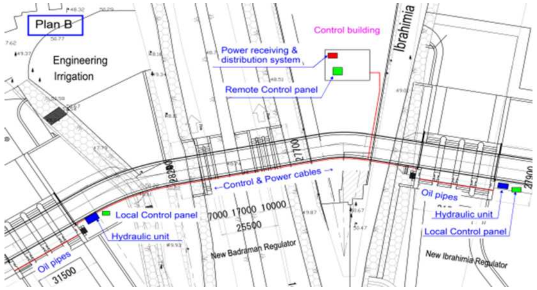
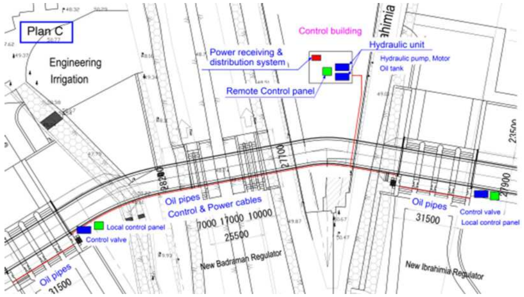
Plan B: Two hydraulic units are placed adjacent to the regulators making local and remote control possible.

Plan C: Only the hydraulic power source is placed in the remote control room, and a switch and control valve are installed at each regulator.

An important between plan A and plan B is the number of hydraulic pipes running from the hydraulic unit to each gate facility. In plan C, hydraulic pipes for four gates are shared and diverted to each hydraulic cylinder at the regulator.

Discussions with the Egyptian government resulted in an agreement to adopt plan B, where the hydraulic unit is placed in the local control room constructed adjacent to the regulator to ensure local control. This system is the same as that of the existing Ibrahimia head regulator.

Table 15-2.1 Comparison between hydraulic hoisting systems

		Plan A	Plan B	Plan C
Diagram		 Plan A Engineering Irrigation Control building Power receiving & distribution system Control panel Hydraulic unit Hydraulic pump, Motor Oil tank Control valve Ibrahimia ←Oil pipes→ Oil pipes 31500 28200 27700 7000 17000 10000 25500 New Badraman Regulator New Ibrahimia Regulator	 Plan B Engineering Irrigation Control building Power receiving & distribution system Remote Control panel Ibrahimia ←Control & Power cables→ Local Control panel Hydraulic unit Oil pipes 31500 28200 27700 27900 7000 17000 10000 25500 New Badraman Regulator New Ibrahimia Regulator	 Plan C Engineering Irrigation Control building Power receiving & distribution system Remote Control panel Hydraulic unit Hydraulic pump, Motor Oil tank Ibrahimia Oil pipes Control & Power cables Local control panel Control valve 31500 28200 27700 27900 23500 7000 17000 10000 25500 New Badraman Regulator New Ibrahimia Regulator
Components	Control house	1) Power receiving and distribution system 2) Hydraulic unit (hydraulic pump, motor, oil tank, control valve) 3) Remote control panel	1) Power receiving and distribution system 2) Remote control panel	1) Power receiving and distribution system 2) Hydraulic unit (hydraulic pump, motor, oil tank, control valve)
	Control house to regulators	Hydraulic pipes (32 pipes×2 lines)	Power cables & control cables	1) Hydraulic pipes (2 pipes×2 lines) 2) Power cables & control cables
	Regulators	1) Hydraulic pipes 2) Hydraulic cylinders	1) Hydraulic unit (hydraulic pump, motor, oil tank, control valve) 2) Local control panel 3) Hydraulic pipes 4) Hydraulic cylinders	1) Control valve 2) Local control panel 3) Hydraulic pipes 4) Hydraulic cylinders
Advantages		1) Since most of the equipment is located in the remote control house, operation and maintenance is easy and security levels are superior. 2) Since the hydraulic pipes are separately connected to a hydraulic power source and an actuator. The risk that all the gates fail to operate at the same time is low.	1) Small space needed in the remote control house for equipment. 2) Both remote and local control are possible. 3) Since the hydraulic pipes are separately connected to a hydraulic power source and an actuator. The risk that all the gates fail to operate at the same time is low.	1) Because the number of pipes laid along the road is small, construction is easier than in "Plan A." 2) Smaller space than "Plan B" needed for equipment in the remote control house.
Disadvantages		1) Because the number of pipes laid along the road is large, construction is not easy. 2) Largest space needed for equipment in the remote control house. 3) Local control is impossible.	1) Since the hydraulic unit is located outdoors, measures against weather and security are required.	1) If troubles arise on the main pipes, there is a possibility that all gates cannot be operated.

15-3 Design of control equipment

15-3-1 Control system

The operation of the gate shall be equipped with local control devices capable of manual operation at the close distance of the hoisting equipment in all facilities, and remote control equipment shall be provided to carry out centralized management of multiple facilities.

The conceptual diagram of the operation control facility is shown in the figure below.

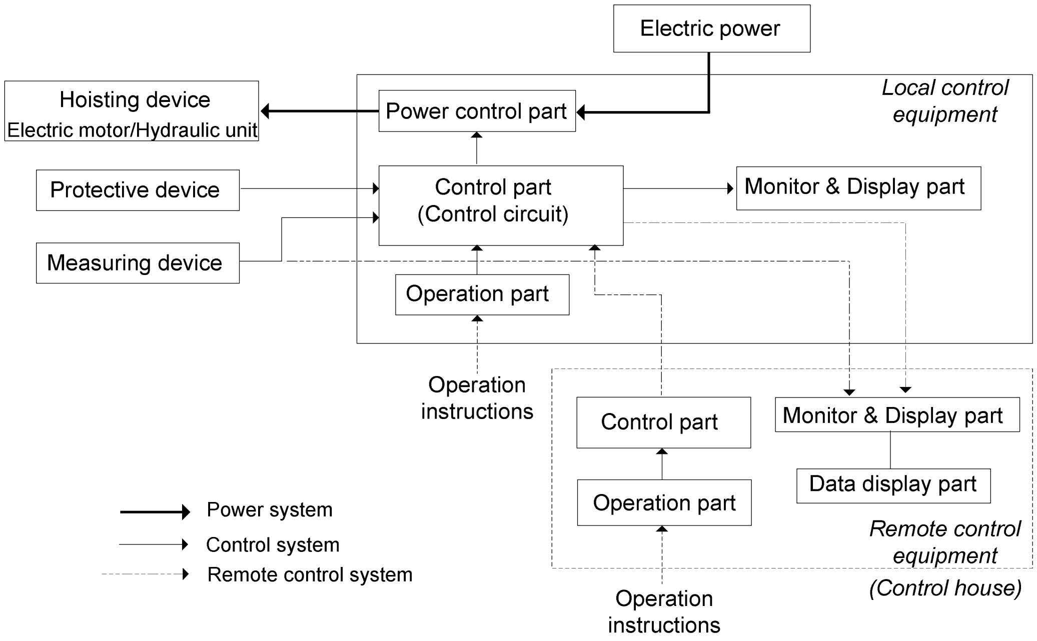


Figure 15-3.1 Conceptual diagram of control and operation

The operational mechanism of the gate is based on the local control, among which the manual operation is a mechanism that can give priority over the automatic control system. Since it is difficult to monitor the gate and hoisting equipment directly by visual observation from a distance, monitoring system to observe the information such as gate opening, status of gate performance and water level should be provided without depending on CCTV (Closed-Circuit Television) that Egyptian government does not want. In addition, the variable-value control method shall be adopted to maintain the set discharge and follow the flow rate or the amount of its change.

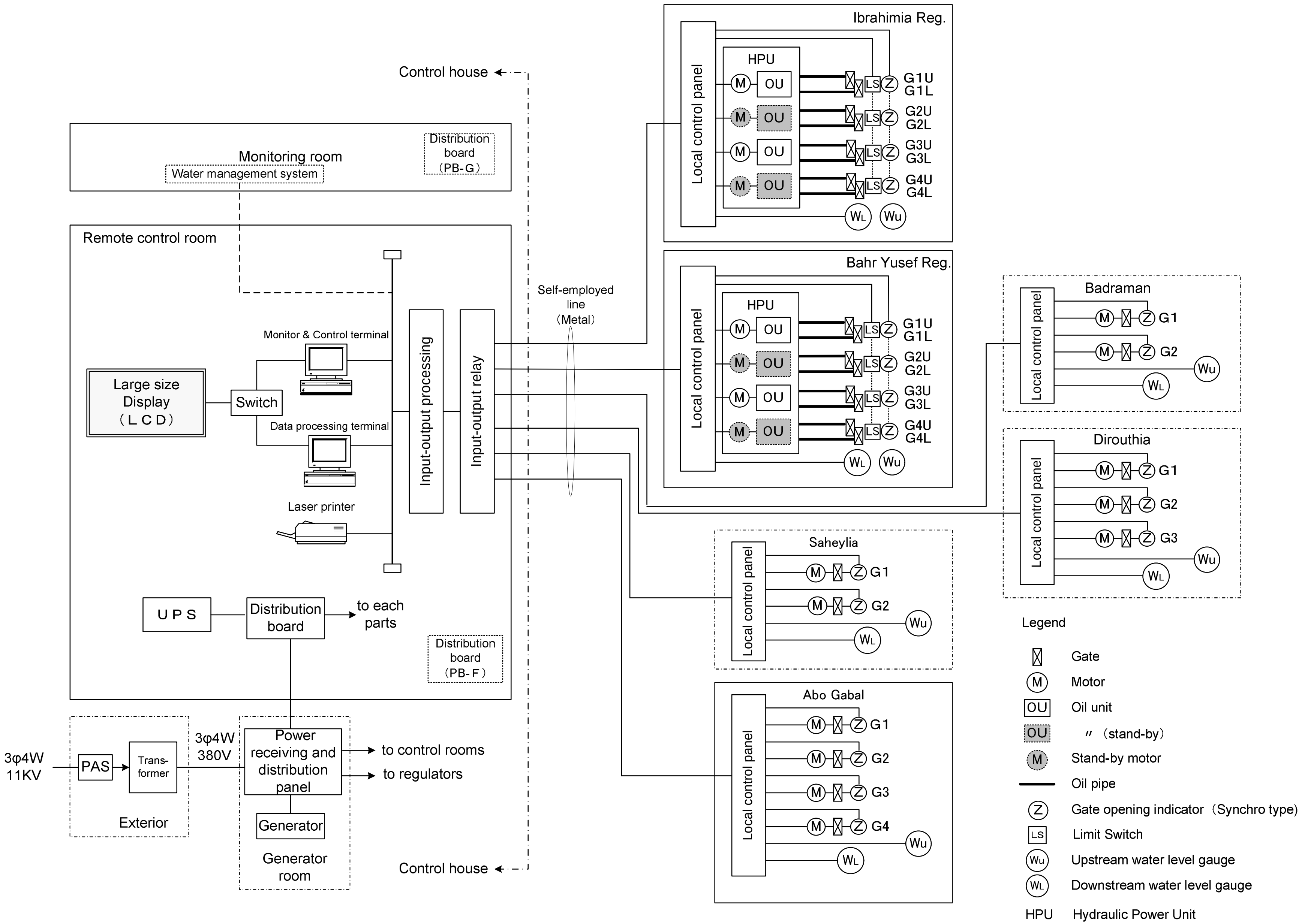


Figure 15-3.2 Monitoring control system configuration diagram

15-3-2 Local control equipment

The local control panel consists of an operation part for operating the gate, a display part for monitoring the operation state, a control part for controlling the operation, and a power supply part for receiving the power supply. The structure of the panel should make it possible to operate the gate precisely and easily, and malfunction does not occur. In order to prioritize the local control rather than the remote control, a switch of local and remote control is provided, and an emergency stop function that makes the gate surely stop by tripping the MCCB (Molded Case Circuit Breaker) for electric motor is provided.

The minimum required status indication items, fault indication and buzzer alarm are as shown in the table below. Also, data transfer between the remote place shall be as follows.

1) Control signal: Control signal such as open / close command from a distance
2) Emergency stop signal: Emergency stop signal from a distance
3) Condition monitoring signal: Operating state monitoring information of the gate from the local side
4) Measurement information: Measurement information such as degree of opening, current and oil pressure from the local side
5) Operating signal: Gate operating signal from local side

Table 15-3.1 Major status indication items

Indication	Status	Electric actuator	Hydraulic actuator	Remarks
POWER SOURCE	Power source on	○	○	
LOCAL	Local control on	○	○	
REMOTE	Remote control on	○	○	
↑	Gate is working to open	○	○	
↓	Gate is working to close	○	○	
UPPER POSITION	Gate is stopped at the upper position	○	○	
LOWER POSITION	Gate is stopped at the lower position	○	○	
PUMP ON	Hydraulic pump is working		○	
OIL PRESSURE ESTABLISHED	oil pressure established under pumping		○	

Table 15-3.2 Major fault indication items

Indication	Detection method	Electric actuator	Hydraulic actuator	Measure to deal with
EARTH LEAKAGE	Leakage relay	○	○	Cause investigation and recovery
3E MOTION	Three element relay(open-phase, phase-reversal and overload)	○	○	Cause investigation and reset
MCCB TRIP	Molded Case Circuit Breaker trips	○	○	Cause investigation
EMERGENCY UPPER POSITION	Limit switch	○		Investigation
OPENING OVER TORQUE	Limit switch	○		Closing the gate and investigation
CLOSING OVER TORQUE	Limit switch	○		Opening the gate and investigation
OVER OIL PRESSURE	Pressure switch		○	Restart after investigation

OIL LEVEL DRAWDOWN	Float switch		○	fix the oil leakage, oil supply
OVER OIL TEMP	Temperature switch		○	Investigation, hydraulic oil cooling

15-3-3 Remote control equipment

In the remote control equipment, it is responsible for displaying the status of the gate, displaying abnormality and alarm, starting and stopping the operation, confirming and resetting the alarm. Switching between the local control and remote control is selected by the switch provided on the local control panel, but when switching to the local operation on the running of the remote operation, the opening and closing operation is immediately stopped. Even when the remote control system fails, the structure of the gate can be operated reliably with the local control panel.

Remote control equipment placed in the control room is composed of followings.

Table 15-3.3 Components of remote control equipment

Name	Main function
Data processing equipment	Data editing, calculation, filing, display / recording, alarm and control processing of each facility are performed.
Monitor & control equipment	From the facility control screen of the personal computer, a remote operation of the gates is performed by the mouse operation.
Printer	In addition to creating various forms for daily reports, monthly reports and operation records and other forms, hard copy printing on the monitor screen is carried out.
Input-output(I/O) processing equipment	Transmission of measuring, monitoring and control signals between the I/O relay equipment and local control panel as well as measuring devices, smoothing of input signal, scaled conversion, data checking, processing to the gate are conducted
Input-output(I/O) relay equipment	Transmission of measuring, monitoring and control signals between the local equipment such as control panel and measuring devices and the I/O processing equipment is carried out. Inductive surge absorption, signal insulation (analogue) to protect equipment from inductive lightning from outside line are performed.
UPS (Uninterruptible Power Supply)	It absorbs various disturbances of the commercial power supply (instantaneous power failure, voltage fluctuation, frequency fluctuation, waveform distortion, high frequency noise, etc.), and supplies uninterrupted and stable power (constant voltage, constant frequency).
Lightning protection transformer	It protects various electronic equipment constituting the system from induced lightning (foreign surge) entering from the external lead-in power line.

The remote operation equipment is placed in the regulators management room inside the control house. Considering the interval required for equipment maintenance and inspection, the minimum size shown in the figure below is necessary.

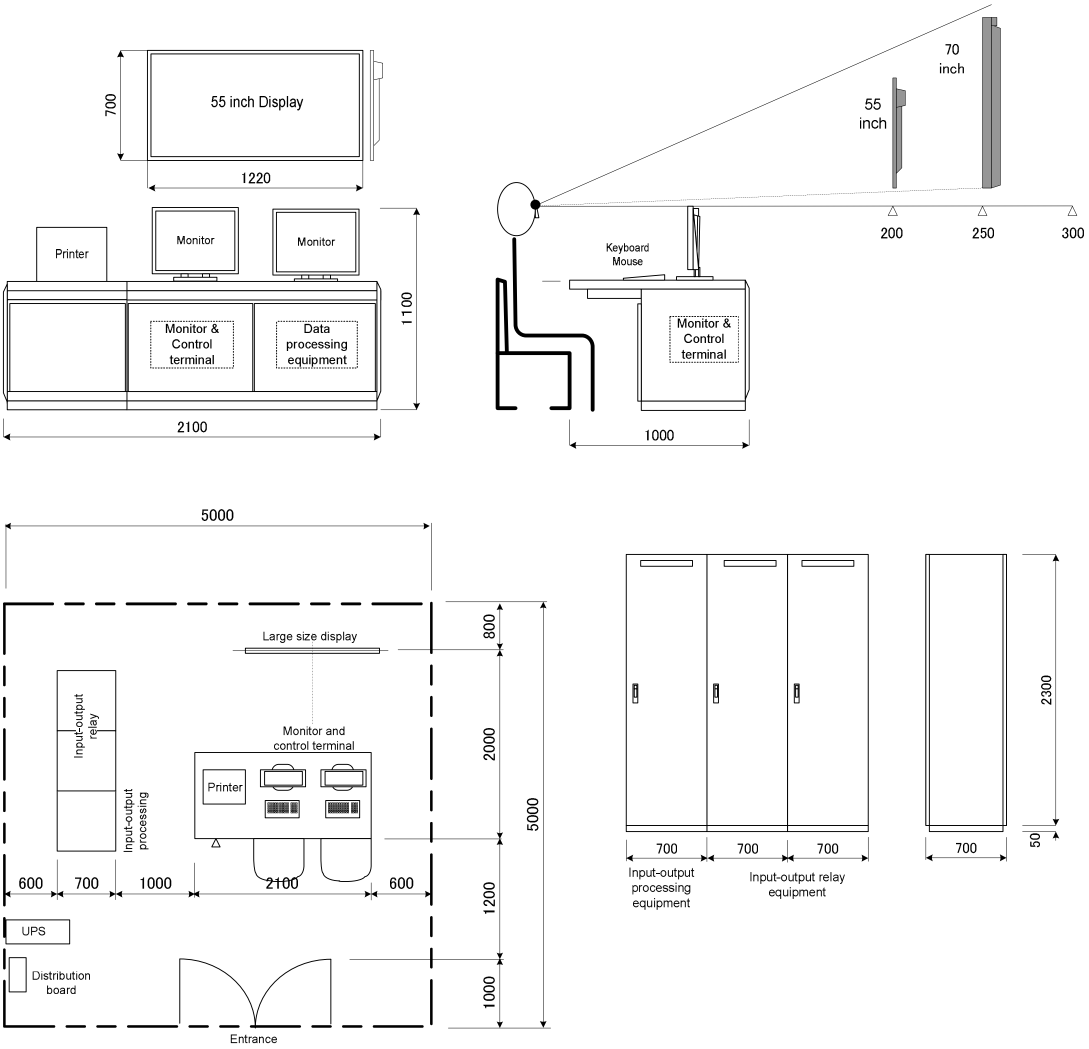


Figure 15-3.3 Minimum layout plan of regulator control room

15-3-4 Information processing equipment

The data processing equipment in the control room mounts and executes all software of the processing function. The control terminal device is equipped with software relating to operation and monitoring of the regulators, and when the data processing device is stopped, the operation terminal backs up basic functions such as data input, calculation, state monitoring, file processing and so on.

Main processing functions by software are as follows.

Table15-3.4 List of information processing function

Item	Function
System management	1.Program management (Activation/Stop/Transmission of operating information) 2.Memory area management 3.RAS (Reliability Availability Serviceability) 4.Time and schedule management 5.Sequence management 6.Event (Alarm/Warning) processing 7.Duplexed management
Calculation	1.Input data (1)Water level (Upstream and downstream) (2)Gate opening (3)Gate status 2.Calculation (1)Scale conversion (2)Calculation of discharge（H-Z-Q table or formula） (3)Trial calculation of gate opening（H-Z-Q table or formula） 3.Tabulation (1)Daily summary（Water level, discharge） (2)Monthly summary（Water level, discharge）
Status monitoring and alarm processing	1.Judgement of upper limit and lower limit（abnormal, alarm, warning, failure restoration） 2.Abnormal condition of devices (detection, alarm, failure restoration）
Display processing	1.Menu 2.Table (value) indication：Latest data, history data、daily report・monthly record, operation record 3.Trend graph indication：relation between water level and discharge 4.Schematic diagram display：Status of facilities 5.Configulation ：Constant value、data modification、time, etc. 6.Remote control display
Record	1.Daily report・monthly record 2.Operation record
Filing	1.Master file 2.External record file 3.Data supplement
Operation processing (Remote control of gate)	1.Control output（On-Off、setup value、output form）

15-4 Design of electric facilities

15-4-1 Power receiving equipment

In addition to securing the capacity for the power load of the gate facility, it is necessary for the power receiving equipment to secure a capacity capable of performing sufficient functions for the entire load equipment including the management load in the control house.

The construction site is in an urban area and it is possible to draw commercial power. The receiving voltage is 11 kV from the load capacity, the power voltage is three-phase four-wire type 380V class, the management voltage is single phase 220V or 100V class. The capacity of the transformer is 100kVA from the total load.

Table 15-4.1 Calculation of load capacity

Load	Capacity (kw)	Number	Voltage (V)	Efficiency	Phase factor	Load capacity (kVA)	Remarks
1.Three-phase							
Bahr Yusef	11.00	2	380	0.85	0.9	28.76	Oil pump
Ibrahimia	11.00	2	380	0.85	0.9	28.76	Oil pump
Badraman	0.65	2	380	0.85	0.9	1.70	Electric actuator
Diroutiah	0.65	3	380	0.85	0.9	2.55	Electric actuator
Abo Gabal	1.00	4	380	0.85	0.9	5.23	Electric actuator
Sahelyia	1.40	2	380	0.85	0.9	3.66	Electric actuator
sub-total						70.65	
2.Single-phase							
Lighting	0.40	6	210	1.00	0.9	2.67	Bahr Yusef& Ibrahimia
Local control panel							
Bahr Yusef	1.30	1	100	1.00	0.9	1.44	
Ibrahimia	1.30	1	100	1.00	0.9	1.44	
Badraman	0.80	1	100	1.00	0.9	0.89	
Diroutiah	1.05	1	100	1.00	0.9	1.17	
Abo Gabal	1.30	1	100	1.00	0.9	1.44	
Sahelyia	0.80	1	100	1.00	0.9	0.89	
Hydraulic unit	2.00	2	210	0.85	0.9	5.23	
【Control house】							
Control devices	5.00	1	100	1.00	0.9	5.56	
Air conditioners	2.00	1	210	0.85	0.9	2.61	
Indoor lighting	2.00	1	210	1.00	0.9	2.22	
sub-total						25.57	
Total						96.22	

Load capacity(kVA)＝Rated capacity(kW)／Efficiency／Phase factor

Power receiving equipment consists of followings.

Table15-4.2 Components of power receiving equipment

Equipment	Function
Incoming transformer panel	It accommodates transformers and switches that receive 3-phase 4-wire 11 kV and step down to 3-phase 4-wire 380 V.
Power receiving and distribution panel	It receives 3-phase 4-wire 380 V, supplies 3-phase 3-wire 380 V and single-phase 380 V / 220 V / 110 V power. Also, at the time of a power outage, it switches from commercial to emergency power generator and supplies uninterruptible power to the load.
Air load switch	A switch provided on the high voltage lead-in line, which is used as a switchgear between the electric power company and the consumer side. Install on the pillar and perform manual opening / closing operation. It also has a ground fault protection function.

15-4-2 Emergency generator

The emergency generator has a structure in which the engine and the generator are integrated, and when the commercial power supply is cut off, it secures the power supply of the power equipment necessary for maintaining the basic function of the gate equipment and the ancillary management equipment. From the viewpoint of noise prevention, cubicle type is recommended, and fuel tank mounting type is recommended for space saving. It can be said that the necessity of securing the power capacity during outage to operate the entire gate facilities, namely five regulators with fifteen gates simultaneously is small considering the current manual operation frequency and the impact on the beneficiary area when the gate operation becomes impossible. Therefore, it is sufficient to secure a power source that can operate one gate of either Bahr Yusef or Ibrahimia regulator with large discharge amount and one gate at a small scale regulator. In addition, in order to be able to manage the operation in the control house even at night, the following calculation was made on condition that the interior lighting functions.

(1) Generator output power

Generator output shall be selected based on the maximum calculated value among PG-1 to PG-3 shown below.

i) Capacity for steady state load (PG1）
ii) Capacity for maximum voltage drop on transient event（PG2）
iii) Capacity for maximum short time tolerance rate on transient event（PG3）
iv) Capacity including harmonic load or single phase load（PG4）

i) Capacity necessary for full load steady operation PG1

$PG1 = \Sigma Po / (\eta * \Phi) \times \alpha \times Sf$（kVA）

ΣPo：Sum of total load output（kW）
η：Efficiency（0.85）
Φ：Phase factor（0.8）
α：Overall demand factor（0.9）
Sf：Coefficient of unbalanced load（When using Scott connection transformer, Sf=1.0)

$Sf = 1 + 0.6 \times \Delta P / \Sigma Po$

ii) Capacity required by allowable voltage drop PG2

$PG2 = Pm \times \beta \times C \times Xd \times (1 - \Delta E) / \Delta E$（kVA）

Pm：Motor output when startup capacity is maximum（kW）
β：Startup kVA per 1 kw on maximum capacity
C：Coefficient by startup method
Xd：Generator constant（0.25）
ΔE：Allowable voltage drop（0.25）

iii)Capacity necessary for starting maximum capacity motor at the end PG3

$PG3 = (fv1 / \gamma g) \times \{(\Sigma Po - Pm) \times (\alpha / \eta \Phi) + Pm \times \beta \times C\}$

$fv1$：Reduction coefficient on loading
γg：Tolerance rate against moment over load of generator（1.5）
ΣPo：Sum of steady load output（kW）
Pm：Motor output when startup capacity is maximum（kW）
α：Overall demand factor（0.9）

η ：Efficiency（0.85）
Φ ：Phase factor（0.8）
β ：Startup kVA per 1 kw on maximum capacity
C：Coefficient by startup method

iv)Capacity required by allowable reversed phase current PG4

$$PG4 = (1/KG1) \times \{(0.432R)^2 + (1.23\Delta P)^2 x(1-3U+3U^2)\}^{1/2} \text{ (kVA)}$$

KG1：Coefficient by allowable reversed phase current of generator（0.15）
R：Sum of harmonic load for generator（kW）, when no harmonic load $R=0$
U：Single-phase unbalanced load coefficient
$U = (A-C)/(A+B-C)$、$A \geqq B \geqq C$
Single phase output value to each phase　A,B,C（kW）
$\Delta P = A+B-2C$

(2) Engine output power

Engine out put of generator must be more than the maximum capacity calculated by the following formulas.

i) Capacity necessary for full load steady operation　PE1

$$PE1 = PG \times \Phi g/\eta g \times 1.36 \quad \text{(PS)}$$

PG：Generator output(kVA）
η g：Generator efficiency
Φ g：Generating phase factor（0.8）

ii) Capacity necessary for starting maximum capacity motor at the end　PE2

$$PE2 = fv2\ \{0.75/\eta'g) \times (\Sigma Po-Pm) \times (\alpha/\eta L) + Pm \times \beta \times C \times \Phi s/(\varepsilon \times \eta'g)\} \times 1.36$$

fv2：Reduction coefficient on loading
η 'g：Over load efficiency of generator（95% of commercial efficiency）
Σ Po：Sum of steady load output（kW）
Pm：Motor output when startup capacity is maximum（kW）
α ：Overall demand factor（0.9）
η L：Overall efficiency of base load（0.85）
ε ：Allowable loading of engine on no load
β ：Startup kVA per 1 kw on maximum capacity
C：Coefficient by startup method
Φ g：Motor startup phase factor when startup capacity is maximum
（Squirrel：0.4、Wire-wound：0.8）

iii)Capacity　for moment over load tolerance rate　PE3

$$PE3 = fv3/(\eta'g \times \gamma) \times \{(\Sigma Po-Pm) \times (\alpha/\eta L) + Pm \times \beta \times C \times \Phi s\} \times 1.36$$

fv3：Reduction coefficient on loading
η 'g：Over load efficiency of generator（95% of commercial efficiency）
γ ：Tolerance rate against moment over load of generator（1.1）
Σ Po：Sum of steady load output（kW）
Pm：Motor output when startup capacity is maximum（kW）
α ：Overall demand factor（0.9）
η L：Overall efficiency of base load（0.85）
β ：Startup kVA per 1 kw on maximum capacity

C：Coefficient by startup method
Φg：Motor startup phase factor when startup capacity is maximum
（Squirrel：0.4、Wire-wound：0.8）

Table 15-4.3 Objective load output for emergency generator

Load	Capacity (kw)	Number	Emergency generator			Remarks
			Actual capacity (kw)	Counted number	Target capacity (kw)	
1.Three-phase						
Bahr Yusef	11.00	2	11.00	2	22.00	Oil pump
Ibrahimia	11.00	2	11.00			Oil pump
Badraman	0.65	2	0.65			Electric actuator
Diroutiah	0.65	3	0.65			Electric actuator
Abo Gabal	1.00	4	1.00			Electric actuator
Sahelyia	1.40	2	1.40	1	1.40	Electric actuator
sub-total					23.40	
2.Single-phase						
Lighting	0.40	6	0.40			Bahr & Ibrahimia
Local control panel						
Bahr Yusef	1.30	1	1.30	1	1.30	
Ibrahimia	1.30	1	1.30	1	1.30	
Badraman	0.80	1	0.80			
Diroutiah	1.05	1	1.05			
Abo Gabal	1.30	1	1.30			
Sahelyia	0.80	1	0.80	1	0.80	
Hydraulic unit	2.00	2	2.00	2	4.00	
【Control house】						
Control devices	5.00	1	5.00	1	5.00	
Air conditioners	2.00	1	2.00			
Indoor lighting	2.00	1	2.00	1	2.00	
sub-total					14.40	
Total					37.80	

Table 15-4.4 Calculation of the capacity of emergency generator

Required capacity of generator

Classification	Coefficient and applied values									Capacity（kVA）
PG1	ΣPo	η	Φ	α	Sf					
	37.8	0.85	0.8	0.8	1.000					44.5
PG2	Pm	β	C	Xd	ΔE					
	11.0	7.2	1.0	0.25	0.25					59.4
PG3	fv1	γg	ΣPo	Pm	α	η	Φ	β	C	
	1.0	1.5	37.8	11.0	0.8	0.85	0.8	7.2	1.0	73.8
PG4	KG1	R	ΔP	U						
	0.15	0	0	0						0.0

Required engine output power

Classification	Coefficient and applied values										Capacity（PS）
PE1	PG	ηg	Φg								
	75	0.857	0.8								95.2
PE2	fv2	η´g	ΣPo	Pm	α	ηL	β	C	Φs	ε	
	1	1.5	37.8	11	0.8	0.857	7.2	1	0.4	1.00	45.7
PE3	fv3	η´g	ΣP0	Pm	α	ηL	β	C	Φs	γ	
	1	1.5	37.8	11	0.8	0.857	7.2	1	0.4	1.10	46.7

From the results of calculation sheets above, emergency generator shall be selected to meet the required specification of 75kVA for generator capacity and 95.2PS (=71.7kw) for diesel engine.

(3)Fuel tank capacity

Fuel consumption rate F is obtained by following equation.

$F = b \times PS / r$

where , b: Fuel consumption rate（＝0.22kg/PS･h）

PS: Output of diesel engine（PS）

r: Specific gravity of fuel（Light oil＝0.83）

Table 15-4.5 Necessary fuel tank capacity

Fuel consumption b (kg/PS･h)	Engine output PS (PS)	Specific weight γ	Fuel consumption F (L/hr)	Continuous run time t (hour)	Required tank T (litter)	Remarks
0.22	100	0.83	27	2	53	
0.22	100	0.83	27	6	159	
0.22	100	0.83	27	12	318	
0.22	100	0.83	27	24	636	

Generally, it is often planned to be able to operate for more than 2 hours in the case of a headwork facility, so a fuel tank of 53 liters or more is necessary according to the calculation results in the above table.

For reference, an example of a model of an emergency generator that satisfies the above conditions is shown below.　This model has a built-in fuel tank and its capacity is 225 liters.

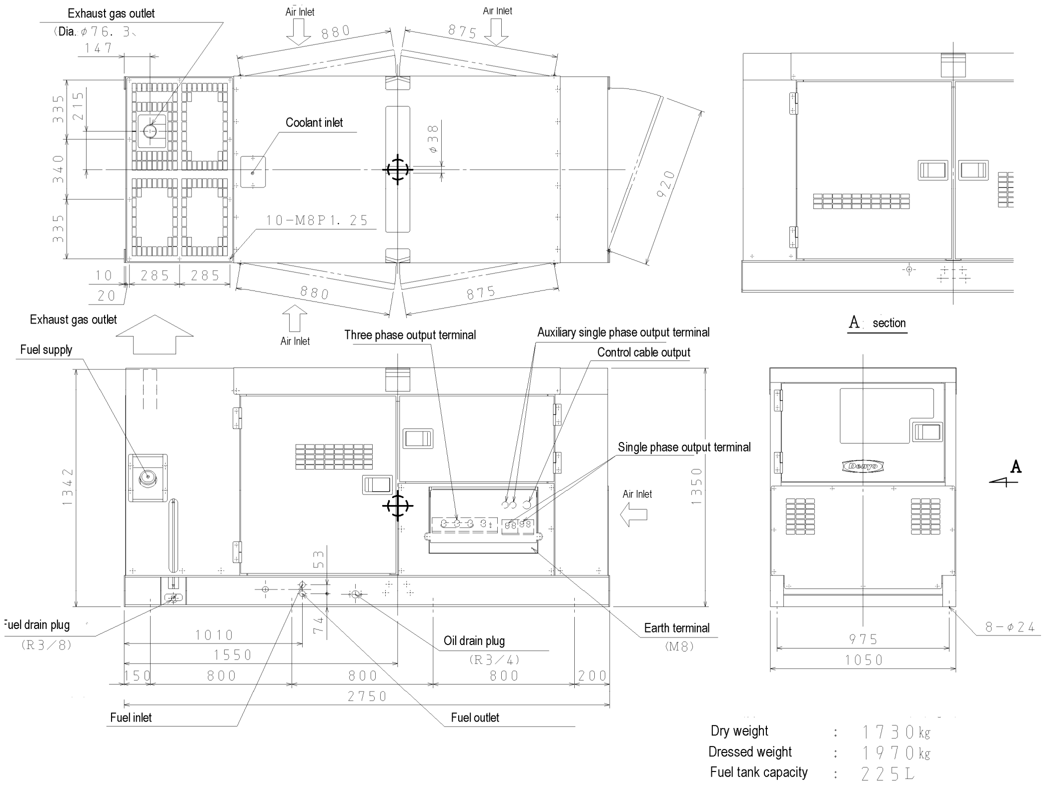


Figure 15-4.1 Outline drawing of an emergency generator

15-4-3 Specification of electric facilities

Minimum requirement of electric facilities are as follows.

I. Control equipment in the control house

1. Data processing equipment (Personal computer)

1）Personal computer body	
a)Memory	2GB
b)HDD	500GB×2（RAID1）
c)Optical drive	DVD drive or equivalent
d)I/O interface	RS-232C、USB、LAN port
e)RAS function	Included
2）LCD monitor	24 inch
3）Keyboard, mouse	Included
4）Operation system	Real-time OS（UNIX or Windows）
5）Power source	AC100V±10V
6）Structure	Tower type or rack mount
7）Placement	Mounted on a desk. Main body is under the desk, display is on the desk.

2. Monitor and control terminal(Personal computer)

1）Personal computer body	
a)Memory	2GB
b)HDD	500GB×2（RAID1）
c)Optical drive	DVD drive or equivalent
d)I/O interface	RS-232C、USB、LAN port
e)RAS function	Included
2）LCD monitor	24 inch
3）Keyboard, mouse	Included
4）Operation system	Real-time OS（UNIX or Windows）
5）Power source	AC100V±10V
6）Structure	Tower type or rack mount
7）Placement	Mounted on a desk. Main body is under the desk, display is on the desk.

3. LBP（Laser Beam Printer)

1)Recording type	Electrographic recording or semiconductor laser and xerographic type
2)Print color	24 bit full color
3)Paper	A3、B4、A4、B5、A5
4)Interface	LAN port
5)Paper feeding unit	2 sets（A4（B5）、A3（B4））
6)Power source	AC100V±10V

4. I/O processing equipment

1）Component	
a）Processing part	
b)Input-output part	Contact input-output, Digital input-output Analogue input-output, Serial input-output
c）Network part	
d)Power source part	
2）I/O interface	
a）I/O relay equipment	Contact, digital, analogue
b)Data processing equipment	LAN（PC-LAN）

3）Power source	AC100V±10V
4）Structure	Indoor self-standing

5. I/O relay equipment

1）Component	
a）Monitoring input part	
Contact input part	Non-voltage contact
b）Measurement input part	
Analogue input part	DC4～20mA
Isolator	I/O insulation
c）Surge Protective Device	for measurement for contact
d)Control output part	
Contact output part	Non-voltage/Voltage contact(Open/Close、Start /Stop, etc.）
e)Power source part	
2）Transmission to external devices	
a）Monitoring signal	Non-voltage contact（DC110V50mA）
b)Analogue signal	DC4～20mA
c)Control output signal	on-voltage/Voltage contact(DC110V50mA）
3）Power source	AC100V±10V
4）Structure	Indoor self-standing

6. Switching hub（OA-LAN）

1)Structure	Desktop type
2)Transmission speed	10Mbps/100Mbps/1000Mbps
3)Reference format	IEEE802.3 10BASE-T IEEE802.3u 100BASE-TX IEEE802.3ab 1000BASE-T
4)Port number	10BASE-T/100BASE-TX/1000BASE-T 8 ports
5)Power source	AC100V±10V

7. UPS(Uninterruptible Power Supply)

1) Rating	Continuous duty
2) Cooling system	Natural air cooling or forced cooling
3) Driving type	Commercial power synchronizing inverter power supply（Hitless switching system）
4) Rated output	3kVA
5) AC input	
a) Phase	Single phase 2 wire
b) Voltage	100V±10V or 200V±20V
c) Frequency	50／60Hz±5％
6) AC output	
a) Phase	Single phase 2 wire
b) Voltage	100V
c) Voltage accuracy	less than ±3％
d) Frequency	50Hz
e) Battery type	Small seal type lead battery
f) Back-up type	10 minutes or more

8. .Lightning protective transformer

1) Rating	Continuous
2) Input power source	
a) Phase	Single phase 2 wire
b) Voltage	100V or 200V

3) Output power source	
a) Phase	Single phase 2 wire
b) Voltage	100V or 200V
4) Frequency	50Hz
5) Ratio of transformation	1:1 or 2:1
6) Capacity	
a) Single phase 2wire	5kVA
7) Cooling system	Dry-type self cooled
8) Ratio of voltage fluctuation	less than 3%（3kVA and more）
9) Surge breakdown voltage	10kV 1.2/50μS
10) Surge extraction rate	Balance: less than -40dB, Unbalance: less than -20dB

9. Distribution panel of devices

1）Structure	Indoor wall-hung type
2) MCCB	3P50AF×2 2P30AF×10

II. Power receiving and transforming equipment

1. Incoming transformer panel

(1) Panel	
1)Type	Outdoor self-standing（front and backside door）
(2)Devices inside of panel	
1） Transformer	
a)Category	Dry molded type
b)Capacity	100kVA
c) Phase	3 phase
d) Voltage	Primary 11kV Secondary 380V-210V
e) Frequency	50Hz
f) Type	Indoor panel housed
g)Cooling	Dial thermometer（with alarm contact）
2）Disconnecting switch (DS)	
a) Rated voltage	11kV
b) Rated current	200A
c) Rated short-time withstand current	12.5kA
d) Operational method	by Hook bar
3）MCCB	4P225AF 1pcs

2. Power receiving and distribution panel

(1)Panel	
1)Type	Indoor self-standing（front door）
(2)Devices of panel face	
1）AC Voltage meter	1 pcs
2）AC current meter	10 pcs
3）Voltage switch	1 pcs
4）Current switch	10 pcs
5）Signal lamp	1 set
6）Switch	2pcs（Auto-manual、Commercial -generator）
7）Push button	5 pcs（Start、Stop、Reset、Emergency stop, failure restoration）
8）Others	1set
(3)Devices inside of panel	
1）MCCB	4P225AF 2 pcs

2）MCCB	4P50AF	1 pcs
3）MCCB	4P30AF	1 pcs
4）MCCB	3P75AF	2 pcs
5）MCCB	3P50AF	6 pcs
6）MCCB	3P30AF	2 pcs
7）MCCB	2P30AF	9 pcs
8）Single phase transformer		1 pcs
Capacity	1KVA 380V/100V	
9）MC	4 pole or equivalent	1 pcs
10）Earth leakage relay		9 pcs
11）CT		9 pcs
12）Others	1 set	

3. Emergency generator

(1)Generator

1）Phase	3 phase 4 wire
2）Frequency	50Hz
3）Output	80kV
4）Voltage	200-400/220-440V
5）Power factor	0.8（lagging）

(2)Diesel engine

1)Type	Direct injection with supercharger
2）Rated speed	1500rpm
3）Fuel	Light diesel oil
4）Fuel tank（on-board）	225L
5）Fuel consumption	9.6/13.5L/h（50％ load/75％ load）

(3)Others

1）Sound（1m）	70dB（A）

4. Generator panel

(1)Structure	Indoor self-standing
(2)Components	
1）AC voltage meter	2 pcs
2）AC current meter	1 pcs
3）Frequency meter	1 pcs
4）Control part	1 set
5）Automatic voltage controller	1 set
6）DC power source （including battery）	1 set
7）MCCB	1 set
8）Others	1 set

5. Air load switch

1）Operation method	Manual
2）Rated voltage	11kVA
3）Rated frequency	50Hz
4）Rated current	400A
5）Direction	yes/no
5）Rated short-time withstand current	12.5kA
6）VT	On-board
7）Material of case	Steel
8）Salinity resistance	yes

9）Accessary	Ground relay、box
10)Option	Over-current relay, main circuit cutoff

III. Gate local equipment

1. Local control panel for electric motor gate

（1）Facilities

Gate type	Electric motor	
Number of gate（n）	Badraman	2 gates（0.65kW×2） n＝2
	Diroutiah	3 gates（0.65kW×3） n＝3
	Abo Gabal	4 gates（1.00kW×4） n＝4
	Sahelyia	2 gates（1.40kW×2） n=2

（2）Panel

1)Type	Outdoor self-standing（front door）

（3）Devices of panel face

1）AC voltage meter	1 pcs
2）AC current meter	n pcs
3）Opening indicator	n pcs
4）Indication lamp（common）	1set
5）Indication lamp（each gate）	n set
6）Push bottom	n×3（stop）
7）Push bottom	3 pcs（reset、emergency stop、failure restoration）

（4）Devices inside of panel

1）MCCB	3P50AF	1 pcs
2) MCCB	3P30AF	n pcs
3) MCCB	2P30AF	5 pcs
4）Single phase transformer	1 pcs（1KVA 380V/200V）	
4）Single phase transformer	1 pcs（1KVA 380V/100V）	
4）Single phase transformer	1 pcs（0.5KVA 100V/100V）	
7）MC	n set（Open、close）	
8）Earth leakage relay	2 pcs	
9）3E relay	n pcs	
10)CT	n pcs	
11）Condenser	n pcs	
12）Synchro current converter		n pcs
13）Supplement relay	1 set	
14）Others	1 set	

2. Local control panel for hydraulic gate

（1）Facilities

Gate type	Hydraulic cylinder type	
Number of gate	Bahr Yusef	4-Upper leaf（Hydraulic pump 11kW）
		4-Lower leaf（Hydraulic pump 11kW）
	Ibrahimia	4-Upper leaf（Hydraulic pump 11kW）
		4-Lower leaf（Hydraulic pump 11kW）

（2）Panel

1)Type	Indoor self-standing(front door)

（3）Devices of panel face

1）AC voltage meter	1 pcs
2）AC current meter	2 pcs
3）Opening indicator	8 pcs
4）Water level indicator	2 pcs
4）Indication lamp(common)	1 set

5）Indication lamp(each gate)	8 set
6）Switch	3 pcs（auto-manual、upper/lower：active-reserve）
7）Push bottom	4 pcs（upper/lower pump start-stop）
6）Push bottom	8×3（gate：open -close-stop）
7）Push bottom	3 pcs（reset、emergency stop、failure restoration）

（4）Devices inside of panel

1）MCCB	3P50AF	2 pcs
2) MCCB	3P30AF	2 pcs
3) MCCB	2P30AF	3 pcs
4）Single phase transformer	1 pcs（1KVA 380V/200V）	
5）Single phase transformer	1 pcs（1KVA 380V/100V）	
6）Single phase transformer	1 pcs（0.5KVA 100V/100V）	
7）MC	4 pcs	
8）Earth leakage relay	3 pcs	
9）3E relay	4 pcs	
10) CT	4 pcs	
11）Condenser	4 pcs	
12）Synchro current converter	n pcs	
13）Supplement relay	1 set	
14）Others	1 set	

3. Distribution panel（Bahr Yusef and Ibrahimia Local control house ）

1）Structure	Indoor wall-hung type
2) MCCB	2P50AF×1 2P30AF×5

15-5 Design of stoplogs

15-5-1 Installation method

Stoplog elements are stored in a warehouse near the control house, and transported from the warehouse to each regulator by truck. A truck crane of a certain capacity will place the stoplog elements into the gate grooves.

A semi-automatic lifting beam shall operate the stoplogs. The lifting beam must be capable of retraction after placing the stoplog elements. The lifting beam shall be equipped with guide rollers and lifting lugs to engage with the hoist.

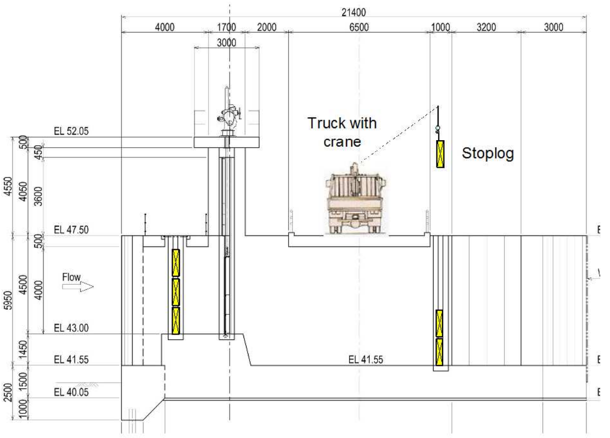


Figure 15-5.1 Stoplog installation method for small regulators

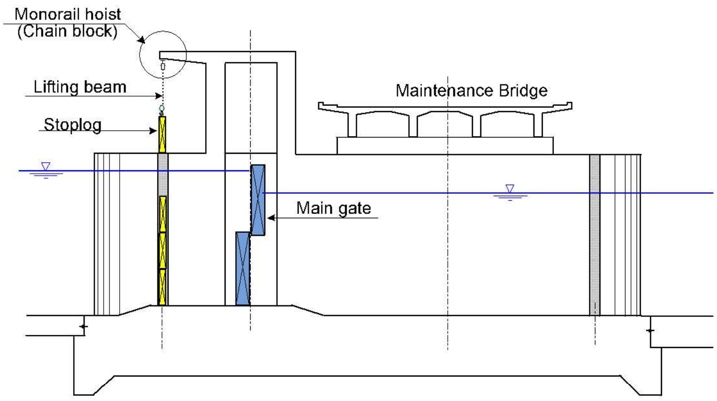


Figure 15-5.2 Stoplog installation method for large regulators (upstream side)

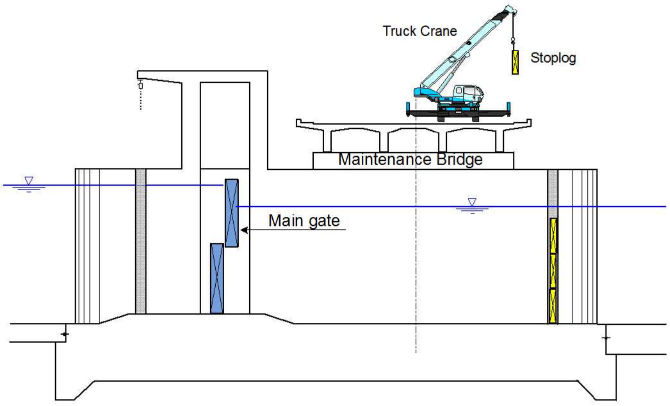


Figure 15-5.3 Stoplog installation method for large regulators (downstream side)

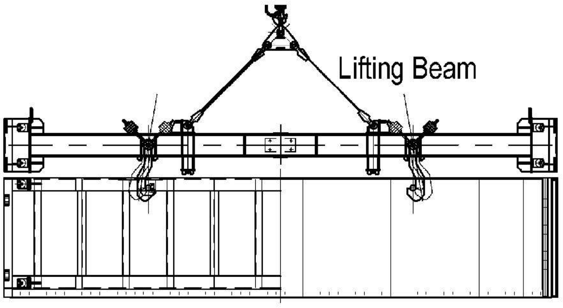


Figure 15-5.4 Lifting beam

15-5-2 Division number of stoplog

(1) Design principles

1) Two types of stoplog, for large regulators and for all small regulators are prepared.

2) Stoplogs are composed of small elements to make it possible to install them by truck crane.

3) Stoplog elements are identical and interchangeable and can be used both upstream and downstream.

4) The heights of elements are set using five 5cm units.

5) The height of any element for a large regulator should be less than 1.4m due to the limited space available to maneuver installation using the lifting beam.

Other basic conditions such as the necessary height of each regulator are shown on the next page.

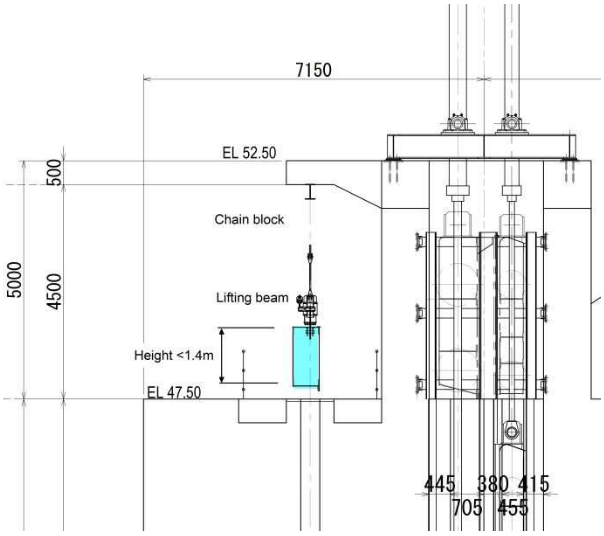


Figure 15-5.5 Maximum height of part of a stoplog for large regulators

(2) Result of study

A case study was conducted based on the conditions mentioned above. Because the required height of stoplogs determined by design water level is different depending on the regulator, the necessary number of pieces which make up the stoplog is also different, especially in the case of the small scale regulators. As a result, some extra height necessarily arises, and the most economical manner by which this extra height is minimized is sought.
Table 15-5.2 and Table 15-5.3 show the results of comparison.

Table 15-5.1 Design conditions of stoplogs

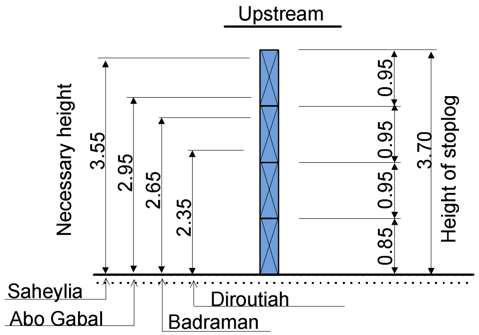
		Large regulators		Small regulators				Remarks
Name		**Bahr Yusef**	**Ibrahimia**	**Badraman**	**Diroutiah**	**AboGabal**	**Sahelyia**	
Type of stoplogs		Sliding	Sliding	Sliding	Sliding	Sliding	Sliding	
Number of stoplogs (sets) 1)		1	1	2				
Clear width of opening		6.00m	6.00m	2.00m	2.00m	2.00m	2.00m	
Upstream (U/S)	Design water level	EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	EL46.30m	NWL
	Gate sill elevation	EL40.00m	EL40.00m	EL43.90m	EL44.20m	EL43.60m	EL43.00m	
	Necessary height	6.55m	6.55m	2.65m	2.35m	2.95m	3.55m	Freeboard=0.25m
Downstream (D/S)	Design water level	EL45.82m	EL45.13m	EL45.90m	EL45.90m	EL45.90m	EL45.90m	
	Gate sill elevation	EL39.50m	EL39.50m	EL43.40m	EL43.70m	EL42.75m	EL41.55m	
	Necessary height	6.57m	5.88m	2.75m	2.45m	3.40m	4.60m	Freeboard=0.25m
Lifting device	Upstream	Manual chain block	Manual chain block	Truck crane	Truck crane	Truck crane	Truck crane	
	Downstream	Truck crane	Truck crane	Truck crane	Truck crane	Truck crane	Truck crane	
Seal type		3-side rubber seal	3-side rubber seal	3-side rubber seal	3-side rubber seal	3-side rubber seal	3-side rubber seal	
Materials	Skin plate	Rolled steel	Rolled steel	Rolled steel	Rolled steel	Rolled steel	Rolled steel	
	Main beam	Rolled steel	Rolled steel	Rolled steel	Rolled steel	Rolled steel	Rolled steel	
	Side roller	Stainless steel	Stainless steel	-	-	-	-	
	Gate guide frame	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	
	Bolt,Nut &Washer	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	Stainless steel	
Deflection		1/600	1/600	1/600	1/600	1/600	1/600	
Allowable stress		According to JIS (Japanese Industrial Srandards) or relevant standards						

Note: 1) One set means a pair of a upstream stoplog and a downstream stoplog for a same vent.

Table 15-5.2 Comparison of the small scale stoplogs

		Badraman		Diroutiah		AboGabal		Sahelyia		Total	Appox. Weight
		Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream		
	Clear width	2.00m									
	Necessary height	2.65m	2.75m	2.35m	2.45m	2.95m	3.40m	3.55m	4.60m		
Option-1	Height of an element	1.55m									
	Number of elements	2	2	2	2	2	3	3	3	6	
	Total height	3.10m	3.10m	3.10m	3.10m	3.10m	4.65m	4.65m	4.65m		
	Extra height	0.45m	0.35m	0.75m	0.65m	0.15m	1.25m	1.10m	0.05m	4.75m	
Option-2	Height of an element	1.15m									
	Number of elements	3	3	3	3	3	3	4	4	8	
	Total height	3.45m	3.45m	3.45m	3.45m	3.45m	3.45m	4.60m	4.60m		
	Extra height	0.80m	0.70m	1.10m	1.00m	0.50m	0.05m	1.05m	0.00m	5.20m	
Option-3	Height of an element	0.95m									
	Number of elements	3	3	3	3	4	4	4	5	9	
	Total height	2.85m	2.85m	2.85m	2.85m	3.80m	3.80m	3.80m	4.75m		
	Extra height	0.20m	0.10m	0.50m	0.40m	0.85m	0.40m	0.25m	0.15m	2.85m	
Option-3A	Height of an element	0.95m (0.85m)*									310(290)kg
	Number of elements	3	3	3	3	4	4	4	5	9	
	Total height	2.75m	2.75m	2.75m	2.75m	3.70m	3.70m	3.70m	4.65m		
	Extra height	0.10m	0.00m	0.40m	0.30m	0.75m	0.30m	0.15m	0.05m	2.05m	

*The value in the parentheses shows the height of one irregular element. But this element is interchangeable with other elements.



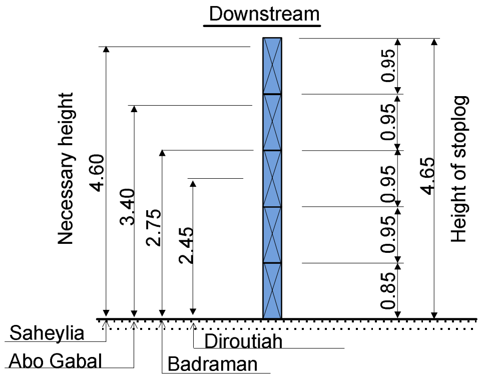
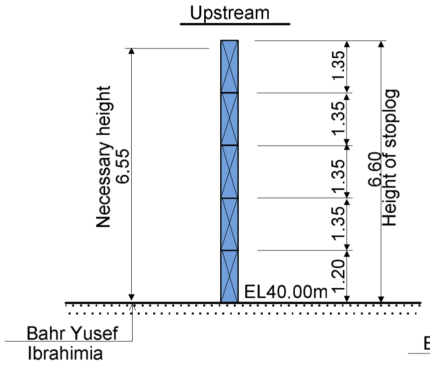
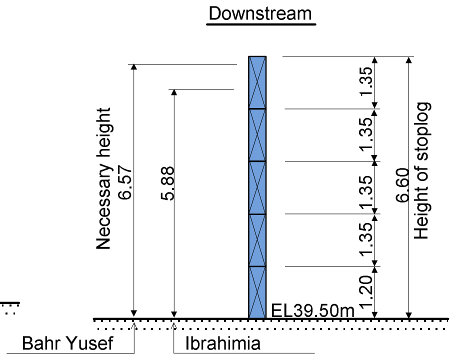


Table 15-5.3 Comparison of the large scale stoplogs

		Bahr Yusef		Ibrahimia		Total	Appox. Weight
		Upstream	Downstream	Upstream	Downstream		
	Clear width	6.00m					
	Necessary height	6.55m	6.57m	6.55m	5.88m		
Option-1	Height of an element	1.35m					
	Number of elements	5	5	5	5	20	
	Total height	6.75m	6.75m	6.75m	6.75m		
	Extra height	0.20m	0.18m	0.20m	0.87m	1.45m	
Option-2	Height of an element	1.10m					
	Number of elements	6	6	6	6	24	
	Total height	6.60m	6.60m	6.60m	6.60m		
	Extra height	0.05m	0.03m	0.05m	0.72m	0.85m	
Option-3	Height of an element	0.95m					
	Number of elements	7	7	7	7	28	
	Total height	6.65m	6.65m	6.65m	6.65m		
	Extra height	0.10m	0.08m	0.10m	0.77m	1.05m	
Option-1A	Height of an element	1.35m (1.20m)*					2.2(2.1) ton
	Number of elements	5	5	5	5	20	
	Total height	6.60m	6.60m	6.60m	6.60m		
	Extra height	0.05m	0.03m	0.05m	0.72m	0.85m	

*The value in the parentheses shows the height of one irregular element. But this element is interchangeable with other elements.





16. Architectural Design

16-1 Design of control house

(1) Planned construction site

Construction site of the control house is near the current office and the mosque between the new Badraman regulator and the new Ibrahimia regulator. The area of about 2,500 m^2 on the north side and about 900 m^2 on the south side is secured across the newly constructed road, and the existing building is relocated and removed by the Egyptian government before the construction work begins.

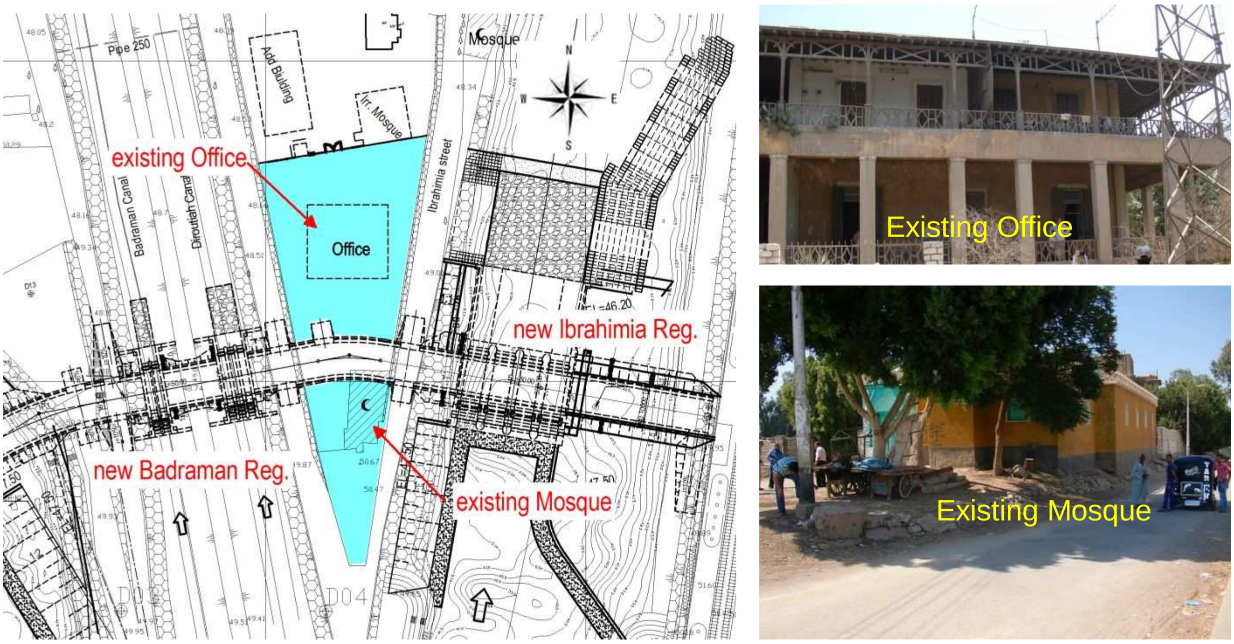


Figure 16-1.1 Present situation of the construction site

(2) Layout plan

In addition to the control house, stoplogs storage house and parking lot are placed in the above construction site.

Since the building area of the control house is assumed to be approximately 200 m^2, it can be placed on either the north side or the south side. However it is administratively advantageous to construct on the south side site that can be visually confirmed the gate facility and the water level condition of the new group of regulators, namely Bahr Yusef, Badraman and Ibrahimia regulator from the side. Meanwhile the construction area of stoplogs storage house is assumed about only 150 m^2, but it is difficult to place it in the south side area with the control house because a site for a crane or a large truck to enter for the purpose of carrying in and out of the stoplogs is necessary besides the building area.

Therefore, the stoplogs house is to be built in the north side site, and the remaining site

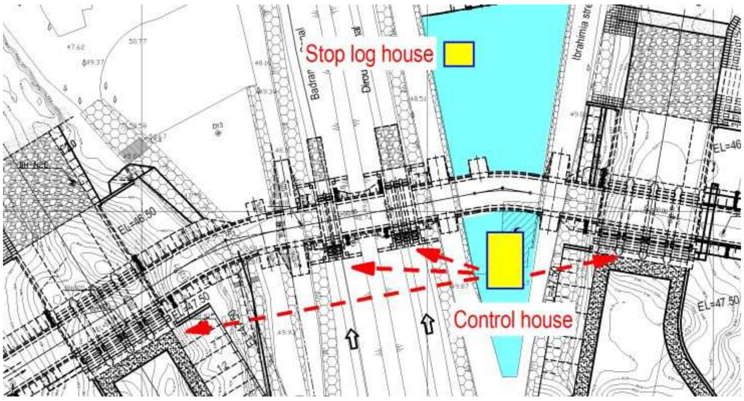


Figure 16-1.2 Layout of control house

is used as the passage and parking space of the vehicle.

(3) Room arrangement

The monitoring room for the integrated water management in addition to the control room of Dirout group of regulators shall be arranged in the control house, with no resident staff. The other rooms to be constructed are as shown below, the layout of them is decided from the characteristics and functions of each room. The control house shall be two stories taking account of the necessary room area for the site area and the points that it is used by two different organizations.

1) Electrical room

It is a room to install the power receiving and distribution equipment as well as emergency generator. Considering the convenience of lead-in of commercial power supply, refueling of the generator and maintenance of the equipment, this room should be placed on the ground floor south side.

2) Control room of regulators

This room is placed on the first floor so that the gate facilities of Bahr Yusef and Ibrahimia regulator and upstream water level can be visually monitored. In addition, a balcony is set around the room for the purpose of monitoring from the outdoors, too.

3) Water management monitoring room

Since the water management system etc. are arranged and monitored, it is located at the position adjacent to the ground floor office.

4) Office

The offices for the integrated water management and Dirout group of regulators management are located on the ground floor and first floor. It is a room where staff perform daily office work, so place it near the first floor entrance or the stairs.

5) Meeting room

It is used for the meeting or the explanations to the visitors. It is placed on the first floor from the relationship between the area required for the meeting and the layout of other rooms.

6) Toilet, washing room

Considering the use of staff and visitors, they are separated by gender, and are set on the ground floor and the first floor respectively.

7) Warehouse

It is set up on each of the ground and first floor for storage of documents, furnishings, etc. and arrangement of servers.

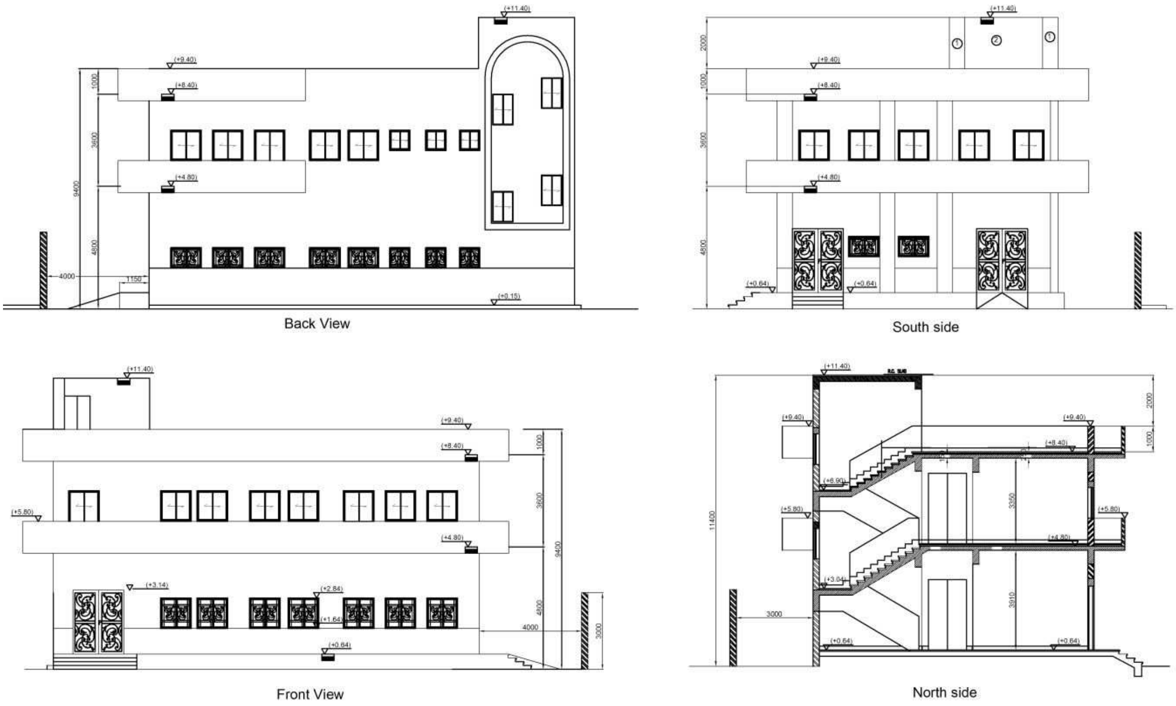
In addition to the above, installation of locker rooms, hot-water supply rooms, reception and guard rooms, rest rooms, shower rooms, etc. were considered, however they were assumed unnecessary from the result of discussion..

(4) Area of rooms

The area of each room was decided to be as shown in the table below as a result of considering the number of staff to be employed, the size and arrangement of the equipment to be installed, the width of the passage necessary for maintenance and inspection, and the layout of the whole floor.

Table16-1.1 Approximate area of rooms

Rooms	Calculation	Remarks
Ground floor		
Monitoring room	5.75 × 6.50 ＝ 37.38	
Power receiving/Generator room	5.75 × 3.90 ＝ 22.43	
Office room	6.90 × 4.40 ＝ 30.36	
Store room(Server room)	2.95 × 3.90 ＝ 11.51	
Toilet/Washing room	3.85 × 3.90 ＝ 15.02	Sub total 116.68
Corridor, Stairs, Hall	3.20 × 10.50 ＝ 33.60	
〃	7.00 × 2.00 ＝ 14.00	
	Sub total 164.3	m^2
First floor		
Control room	5.75 × 10.50 ＝ 60.38	
Office room	3.10 × 4.40 ＝ 13.64	
Meeting room	7.00 × 4.40 ＝ 30.80	
Store room	2.95 × 3.90 ＝ 11.51	
Toilet/Washing room	3.85 × 3.90 ＝ 15.02	Sub total 131.34
Corridor, Stairs, Hall	10.25 × 2.00 ＝ 20.50	
〃	3.20 × 3.90 ＝ 12.48	
	Sub total 164.3	m^2
	Total 328.6	m^2
Traffic part	80.58	32.5%
Room area	248.02	

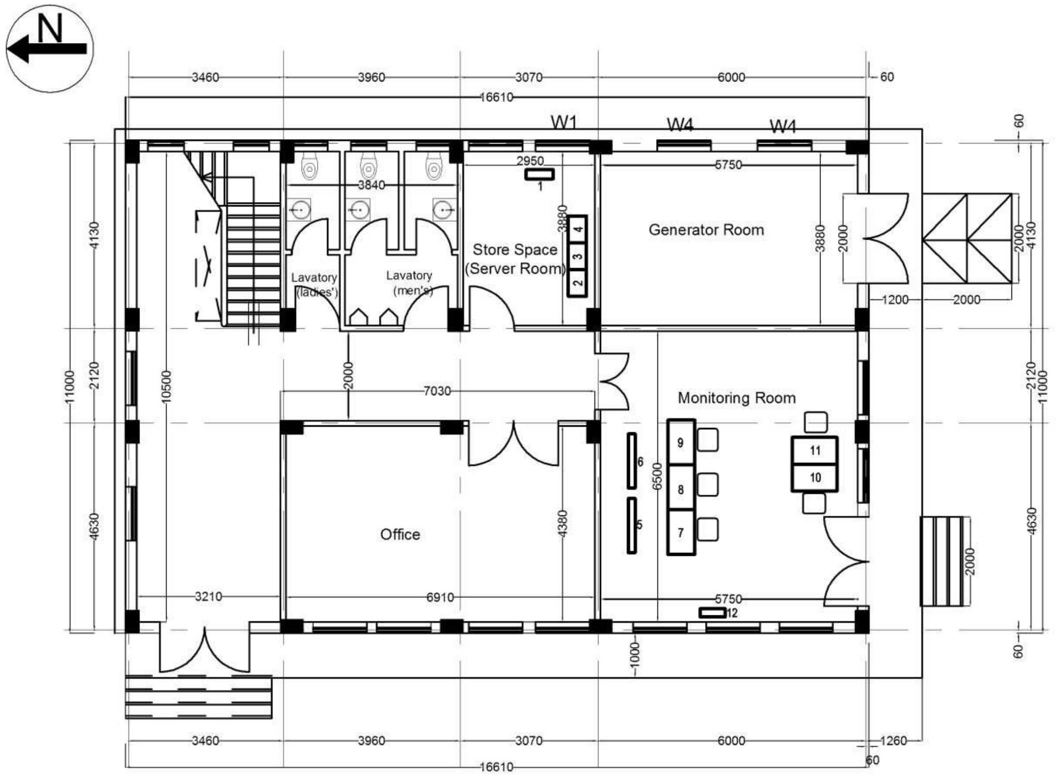

Back View

South side

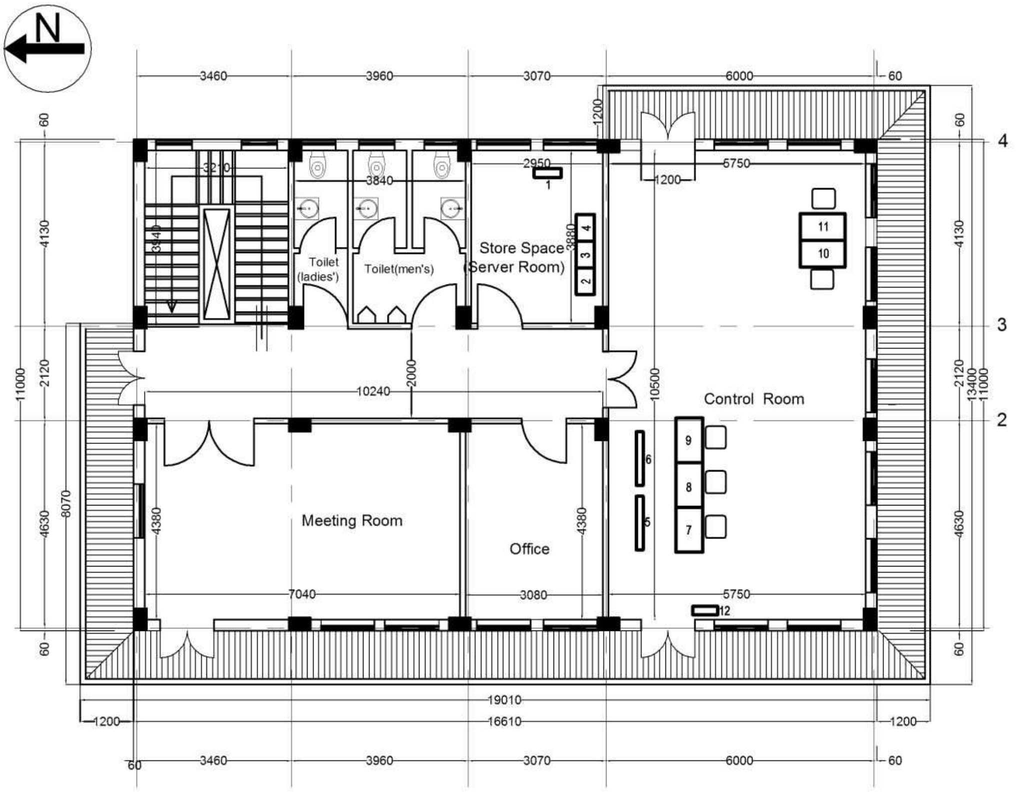
Front View

North side

Figure 16-1.3 Elevation view of control house



Central Monitoring House for Integrated Water Management
Ground Floor



Control House for New Dirout Group of Regulators
First Floor

Figure 16-1.4 Floor plan of control house

(5) Disaster prevention equipment

1) Fire protection facility

Fire detector and alarm equipment shall be provided in each room, fire extinguish equipment shall be installed on each floor. Fire protection facilities are also provided in the local control rooms and the stop log house which are described in the following chapters.

2) Lightning protection system

Considering that the building height is about 10m and the frequency of occurrence of lightning strikes in the construction area, lightning protection facility shall not be provided.

16-2 Design of local control house

(1) Size of local control room

For the Bahr Yusef and the Ibrahimia regulator, a building that houses the hydraulic unit together with the local control panel is installed at a location adjacent to the regulator to protect the equipment from wind and rain, etc., and to ensure safe operation of the gate from within the operation room. The size of the operation room is decided in consideration of the arrangement of the hydraulic unit, local control panel and workability of them during operation, inspection, maintenance and replacement work.

The distance from the front of the hydraulic unit to the wall or other equipment is 100cm or more, and the three sides other than the front are separated by at least 60cm in consideration of tank cleaning, equipment inspection, etc. Even when inspection from the back side is unnecessary, a space of 60cm or more should be secured considering repainting work. Likewise, the local control panel secures a space of 100cm in front and 60cm or more around the panel except the front.

As a result of studying the arrangement based on the assumed size of hydraulic unit, the separately placed hydraulic tank, and the local control panel, it is decided that the interior dimension is 7.5m × 6.5m as shown in the Figure 16-2.1.

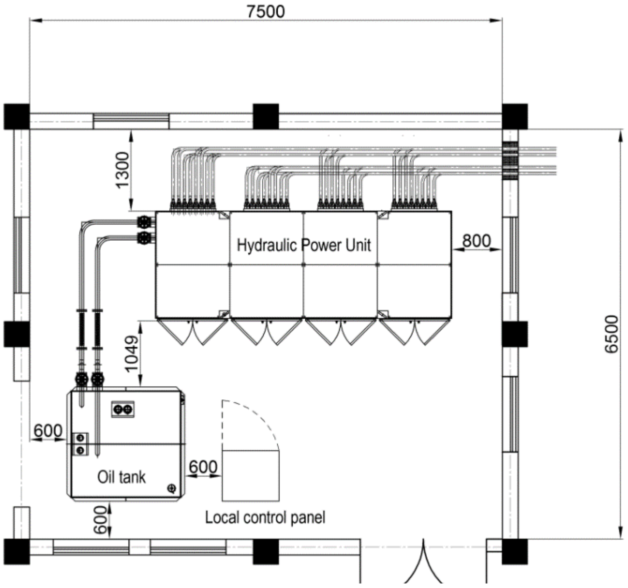


Figure 16-2.1 Layout of local control house

(2) Determination of construction site

1) Bahr Yusef regulator

Construction site of the local control house shall be the upstream side of the regulator so that the length of hydraulic pipe from the operation room to the hydraulic cylinder can be made as short as possible and the operation can be carried out visually confirming the state of the gate.

On the upstream side of the Bahr Yusef regulator a wide flat site is created by the steel sheet pile wall on the left bank side, whereas the right bank side can not secure enough site to build the control house. Therefore, a local control house is constructed on the upstream left bank side. In addition, in the upstream part of the left bank, the truck with the maximum loading capacity of about 4 tons will enter to the vicinity of the side pier of the regulator for carrying in and out of the stoplogs. For this reason, the house shall be constructed at a position 15m away from the side of pier considering the traveling locus of the truck. In addition, the stairway leading to the top of pier where the gate hoists are installed is constructed on the right bank side opposite to the side on which the stoplogs are carried in and out.

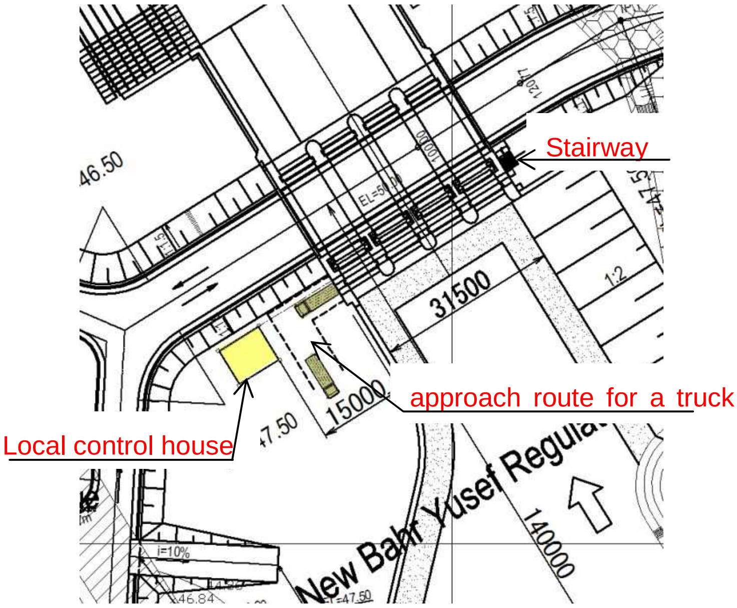


Figure 16-2.2 Layout plan for Bahr Yusef side

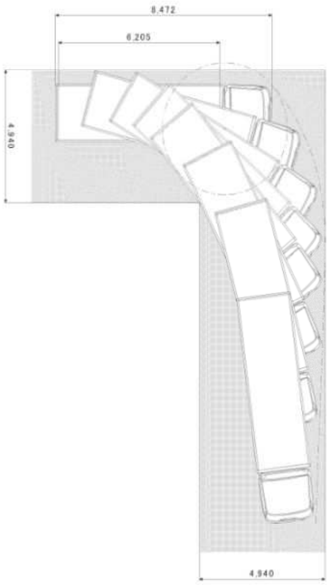


Figure 16-2.3 Travelling locus of truck

2) Ibrahimia regulator

With the same concept as the Bahr Yusef regulator, it is desirable to construct the local control house on the right bank upstream side where large area is created and it is convenient for management. However, access roads route running parallel to national railway, which are planned to be designed by the Egyptian government in the future, is assumed as shown by the broken line in the figure below.

Therefore, the local control house may interrupt the planning road route if the house is constructed at the same position as the Bahr Yusef regulator in consideration of the track entry path for carrying in and out of stoplogs. In addition, since access routes from the road (road surface elevation is about 50.0m) to the left bank side site (EL 47.50m) are also required, installation of the local control house on the right bank also interferes the travelling of vehicles for maintenance work. As a result of discussion with the Egyptian government, the local control house of the Ibrahimia regulator was to be installed on the downstream side of the right bank.

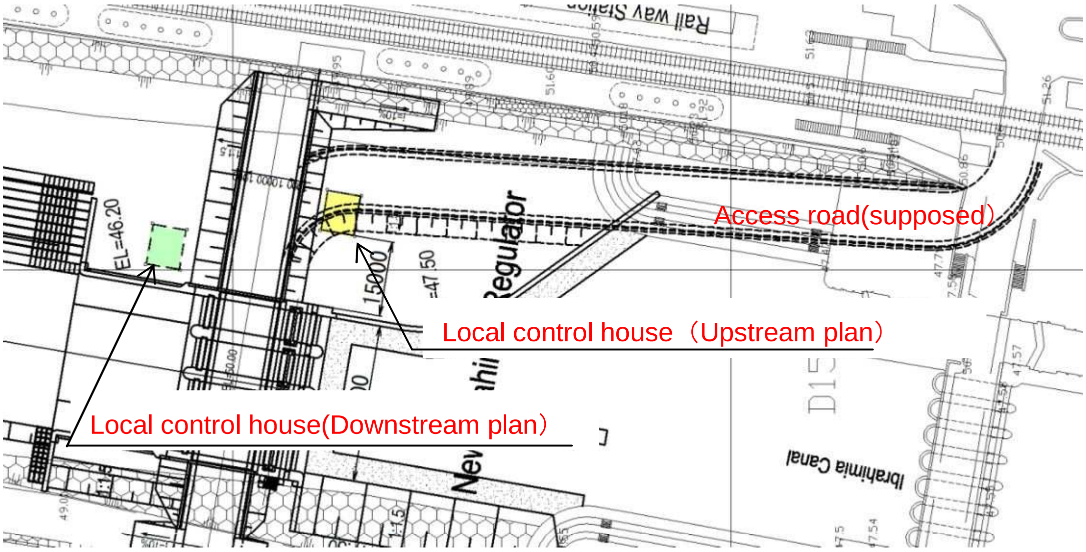


Figure 16-2.4 Layout plan for Ibrahimia side

16-3 Design of stoplogs storage house

(1) Storage equipment

The size of the stoplogs and the number of divisions were as follows as a result of the above examination. Although there is a method of keeping them outdoors without setting up a shed, it is desirable to keep the gates in a good condition for a long time and store it indoors so that it can be used without trouble at any time during main gate repair. In addition, workability is improved if a device is installed in the house that assists loading and unloading on the transportation vehicle.

Table 16-3.1 Size and quantity of stoplogs

	Small regulators		Large regulators		Remarks
	Type A	Type B	Type A	Type B	
Clear span length	2.00m	2.00m	6.00m	6.00m	
Gate height	0.85m	0.95m	1.20m	1.35m	
Quantity	4	14	4	16	
Estimated weight					
per one gate leaf	291.4 kg	311.1 kg	2074.5 kg	2214.6 kg	
Lifting beam	252.5 kg		911.7 kg		

(2) Method of carrying in and out

As a result of proposing the following two plans as a carrying in and out method of the stoplogs, plan B was adopted from the point of economy and difficulty in procurement of construction machine.

Table 16-3.2 Comparison of carrying in/out method

Item	Plan A	Plan B
Carrying method	Operate the manual traveling device installed on the truck to take out the carriage outdoors and load it onto a transport vehicle with a truck crane.	Lift a stoplog using a rail placed on the ceiling of the house and a manual chain block and load it on the transport vehicle in the warehouse.
Storage method	Fix some stoplogs on the storage stand for keeping them upright at regular intervals and store them with the carriage.	Secure and store some stoplogs on the storage stand for keeping them upright at regular intervals.
Building size	Since it can be a space only for the stoplogs storage, it is smaller than the plan-B and the height can be reduced. Approximate 15m×16m	Space for vehicle entry is necessary, and the size and height are larger than the plan-A. Approximate15m×20m (in case of single stack）
Economy	Including storage trucks and rail equipment for traveling is somewhat more expensive than plan-B.	Construction cost of the building itself is rather large, but it is inexpensive to include auxiliary equipment.
Other special instruction	Although the use of a truck crane of about 25t hanging is premised, its procurement is not easy in terms of cost.	Since the stoplogs are moved and loaded one by one, workability is inferior, but a large crane is unnecessary.

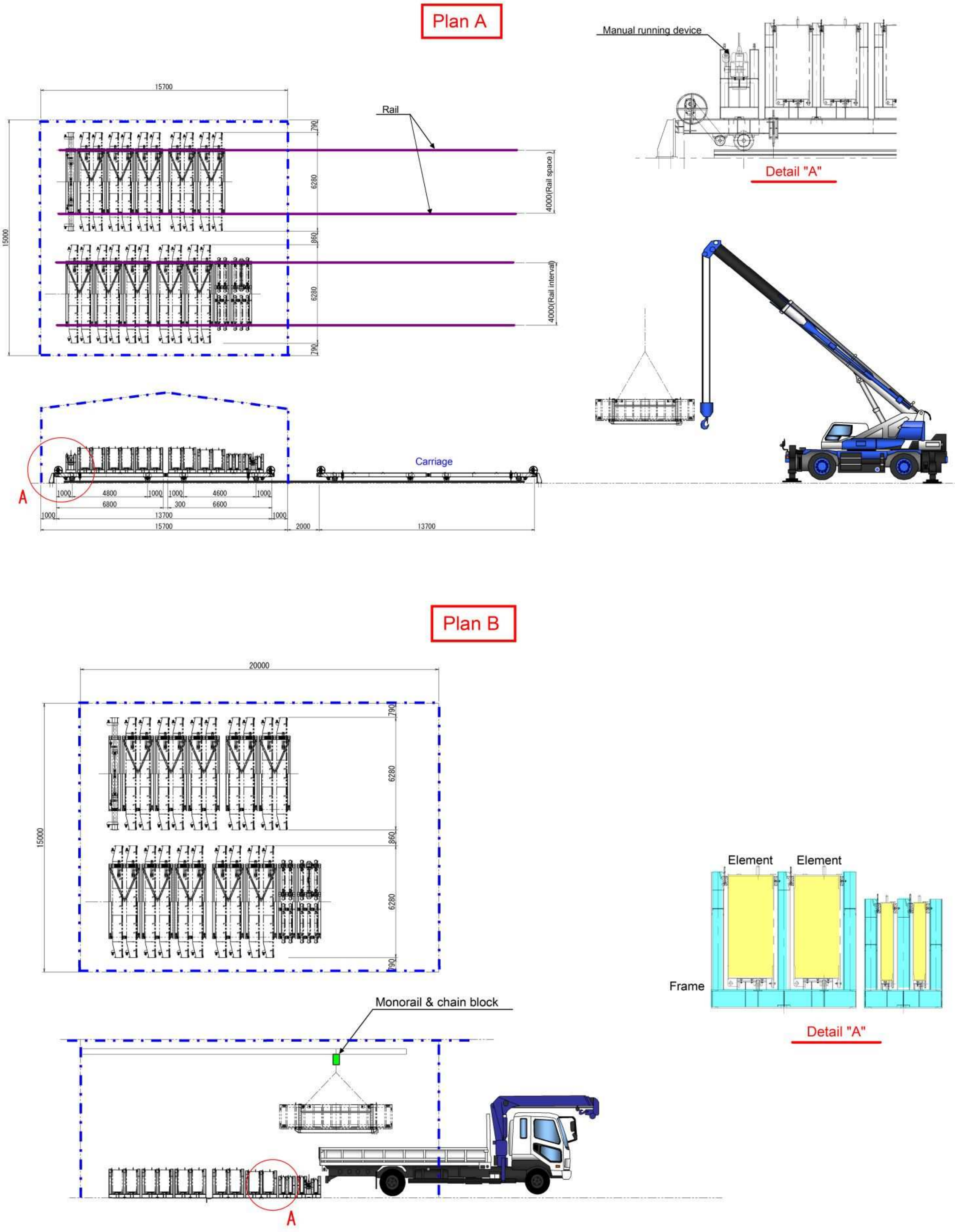


Figure 16-3.1 Study of carrying in and out method for stoplogs

(3) Study of construction area

As a result of examining the storage method to minimize the building area as much as possible, it was decided that the stoplogs for small scale regulators and large scale regulators are stacked in two layers as shown in the figure below. Considering the extra space for internal work, the size is 13.0m × 10.9m = 141.7m^2 in inner dimension. As mentioned above, it is built on the north side site on the opposite side across the road from the control house.

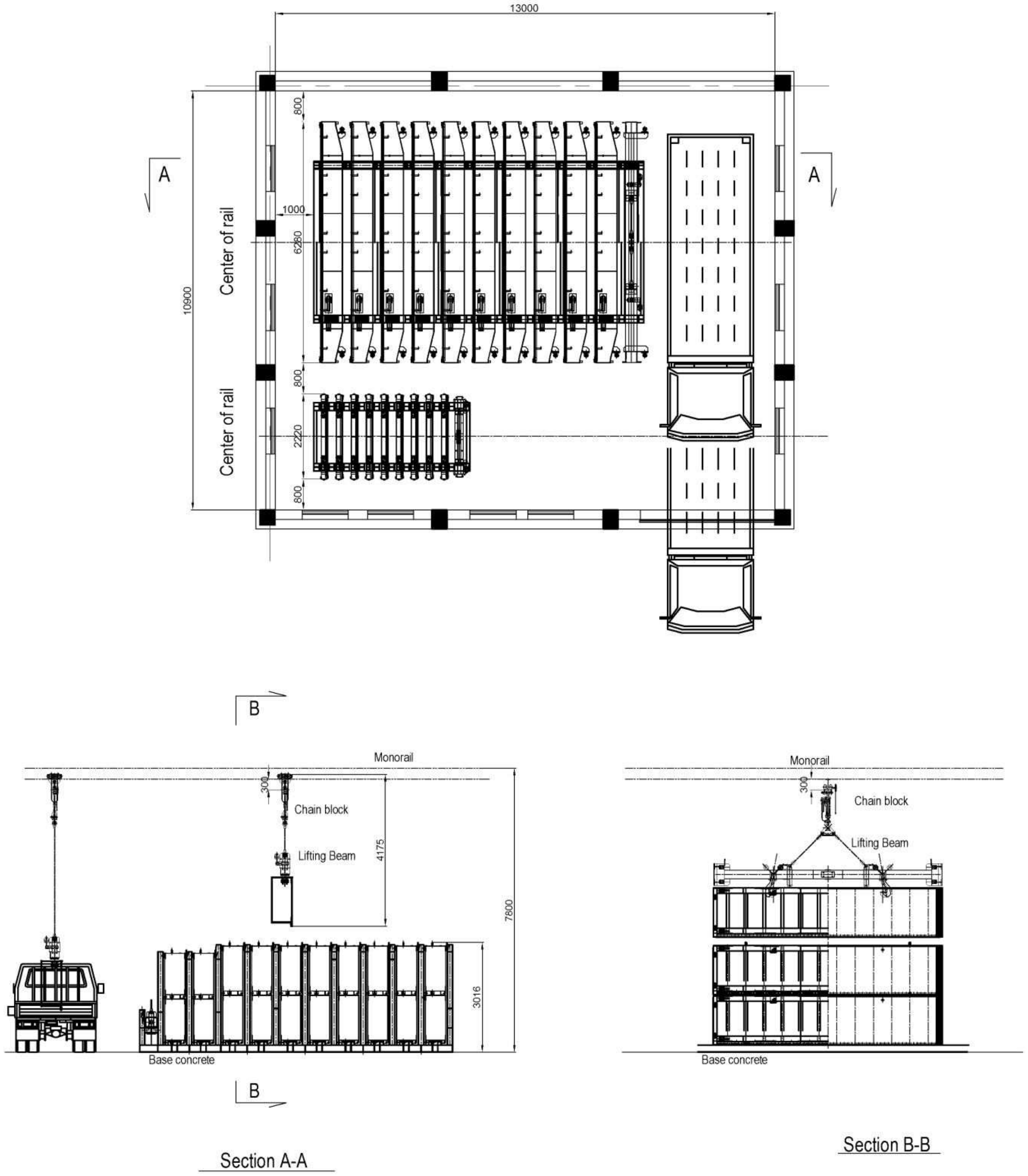


Figure 16-3.2 Layout plan inside the stoplogs house

17. Design of Auxiliary Facilities

17-1 Instrumentation equipment

In order to manage flow discharge properly, water gauges are installed to NDGRs.

(1) Type selection

Although there are several types of water gauges from the aspect of the detection mechanism, pressure type is recommended in consideration of accuracy and easiness of installation.

(2) Places to be installed

In order to manage the water level and calculate the flow rate, it is necessary to grasp the upstream and downstream water level in addition to the gate opening degree. For this reason, the water level gauges are installed at a total of 13 places, two places in each of the regulators (waterways) . The location of installation shall be a place where there is no influence of water level due to intake water or inflow water from the upstream and of wind wave as well as a convenient place for management. The positons proposed are shown in the figure below. To avoid the influence against floating debris or muddy soil, protection pipes should be installed. Also, to check the water level record, staff gauge shall be provided.

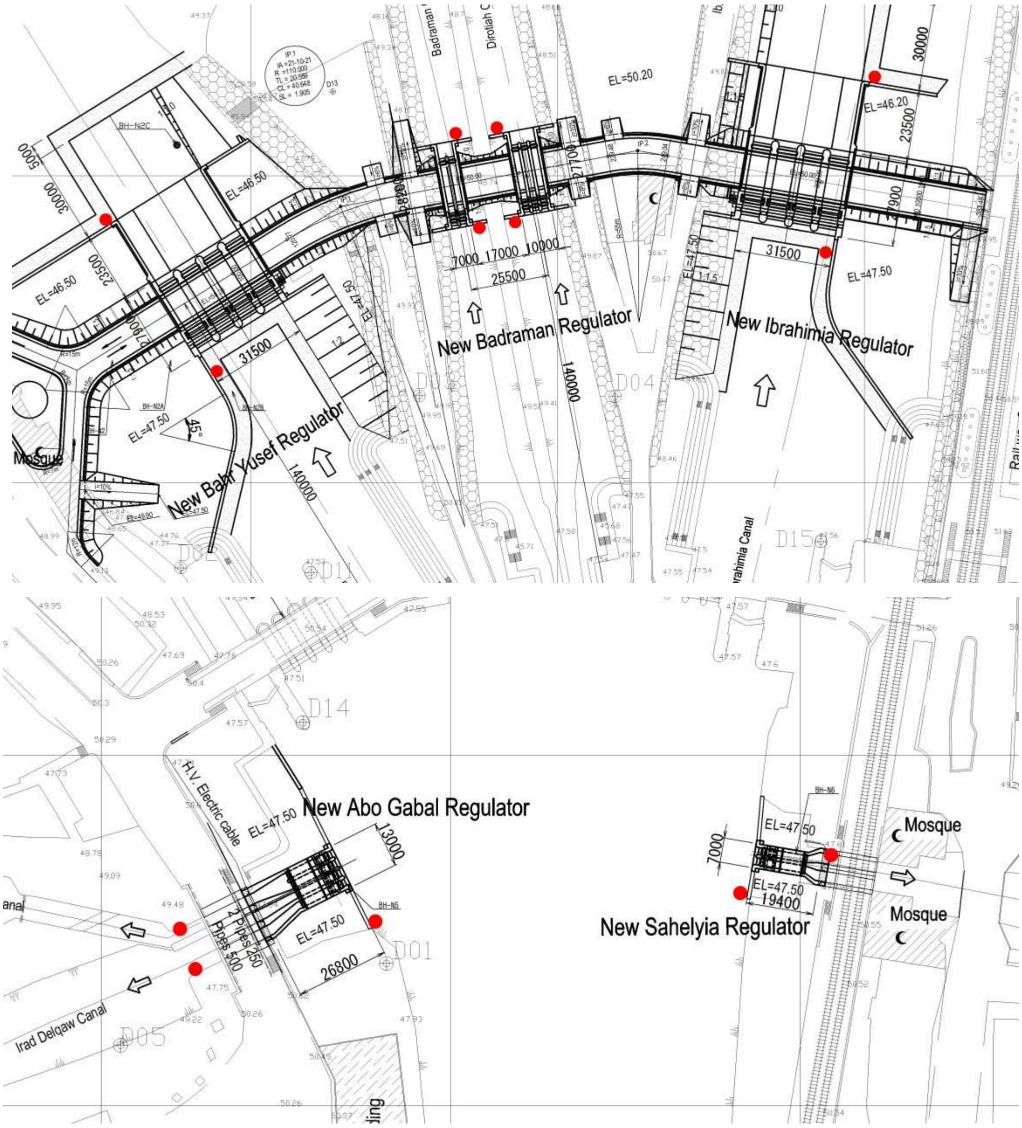
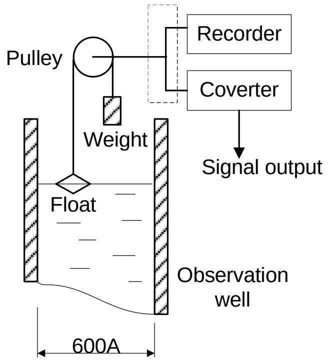
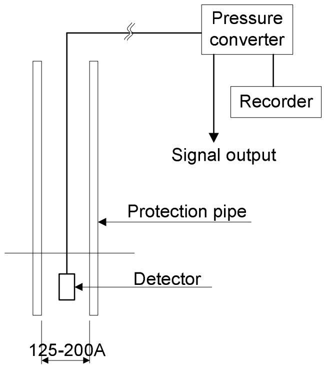
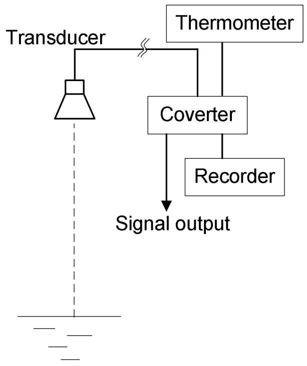


Figure17-1.1 Location of water gauges

Table17-1.1 Types and specifications of water gauges

Type	**Float type**	**Pressure type (Crystal type)**	**Ultrasonic wave type**
Mechanism	Water level is measured by the rotation angle of the pulley which is connected to the float fluctuated by the water level.	The difference of water pressure measured by the detector placed in the water is changed to electrical signal and converted to water level.	Ultrasonic waves are shot toward the water surface and the water level is shown through converting the time measured until receiving the reflection.
Figure	 Recorder Pulley Coverter Weight Signal output Float Observation well 600A	 Pressure converter Recorder Signal output Protection pipe Detector 125-200A	 Transducer Thermometer Coverter Recorder Signal output
Measurement range and accuracy	±1cm (0-10m） Shaft encoder type	±0.01%xFull Scale (±1cm /0-100m）	±1cm (0-10m）
Electric source	Not necessary	Necessary	Necessary
Temperature condition	-10 ^{o}C ～40 ^{o}C	Detector: -10 ^{o}C～70 ^{o}C Converter: -10 ^{o}C～50 ^{o}C:	Transducer: -20 ^{o}C～70 ^{o}C Converter: -10 ^{o}C～40 ^{o}C:
Output signal	Digital	Digital or Analog	Digital or Analog
Characteristics	1)Continuous measurement is possible. 2)Inclined installation is impossible. 3)Large observation well is necessary.	1) Accuracy is high. 2)Continuous measurement is possible. 3) Protection pipe is required but it is small. 4)Inclined installation is possible.	1)Continuous measurement is possible. 2)Transducer should be installed vertically toward the water surface. 3) Initial cost is high.

17-2 Road crossings

Since the local control house of Ibrahimia regulator was to be constructed on the downstream side of the regulator, the external hydraulic piping connecting the hydraulic cylinder and the hydraulic pressure generating device (hydraulic unit) installed inside the house must cross the road.

In principle, the hydraulic piping should be stored in the pit for maintenance and inspection and safety consideration except that it is underground piping in the case of traversing the riverbed. If an accident such as leakage of oil happens and obstructs the operation of the gate in the case of underground burial and direct burial in concrete, it is necessary to dig down the piping and restore it. This is undesirable considering the influence on traffic and a period required for recovery. Therefore, culvert structure shall be constructed under the road and the pipes shall be laid inside of it.

(1) Cross section of the culvert

The inner height of culvert shall be 1.8m or more for persons to enter for maintenance inspection. A total of 32 stainless steel pipes with a nominal diameter of 32A are to be placed inside the culvert, and they are fixed at certain intervals using supporting steel materials. Considering the area occupied by piping as shown below and the space for maintenance and inspection work, the culvert has a cross sectional shape of 1.8m in inner height and 1.8m in inner width and it is made of reinforced concrete.

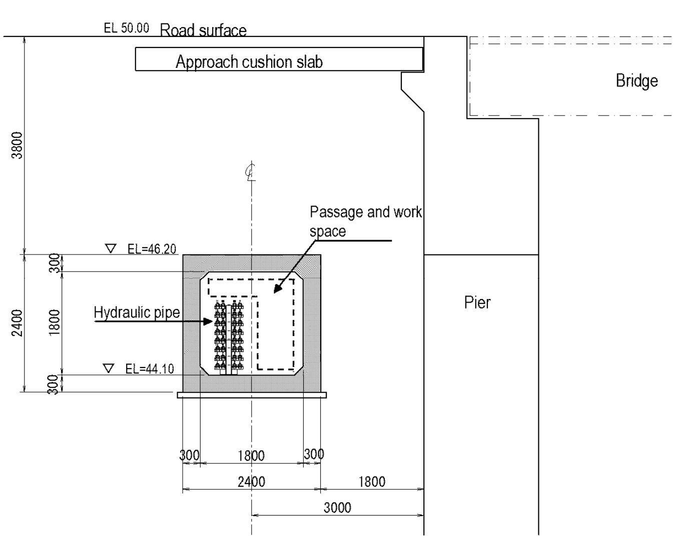


Figure17-2.1 Cross section of culvert

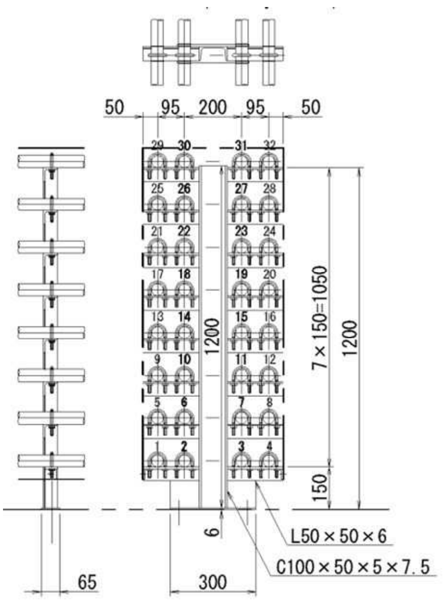


Figure17-2.2 Hydraulic piping inside the culvert

The top elevation of culvert shall be EL 46.20m in agreement with the ground altitude on the downstream side where the local control house is built. Although it is economically advantageous if the crossing position becomes closer to the regulator because the length of pipes also becomes shorter, the center of the culvert shall be 3.0m from the pier in consideration of necessary space for formwork and scaffolding during construction.

(2) Span arrangement

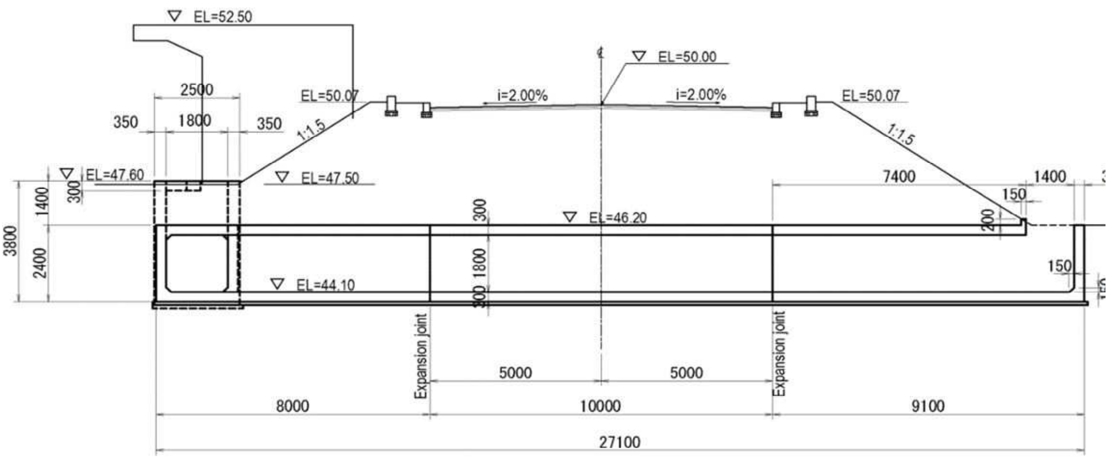


Figure17-2.3 Span arrangement in longitudinal direction

Since the culvert length in the longitudinal direction is close to 30m, it is divided by providing a joint for the purpose of preventing damage of the structure from the influence of drying shrinkage and unequal settlement after construction. The position of the joint shall be divided into three with a length of about 10m as shown in the figure avoiding the vicinity of the center of the road. An elastic material is used for the joint, and the dowel bar method is adopted to cope with the unequal settlement.

(3) Structural design

As load to be used for box culvert design, self weight, vertical earth pressure, horizontal earth pressure, live load, and water pressure are taken into consideration. Combinations of loads used for calculation of section force are calculated for the following two cases and the larger value of bending moment and shearing force at each point is considered.

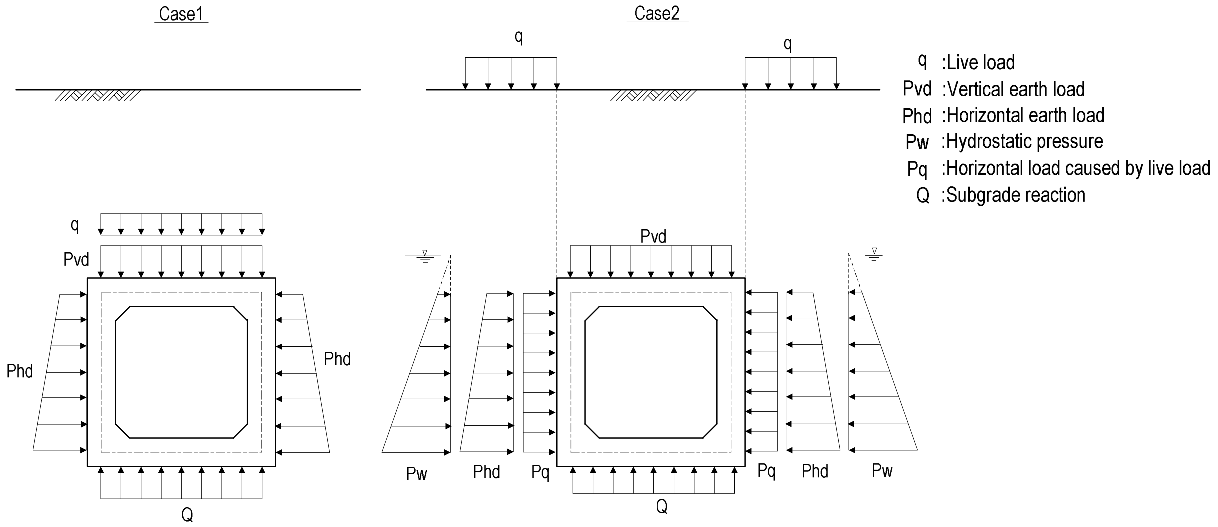


Figure17-2.4 Combined load to the culvert

The result of structural calculation on assumed cross section is shown in following table.

Table 17-2.1 Result of the structural calculation of box culvert

Check point	Side wall			Top slab		Bottom slab		Remarks
	Center	Bottom end	Top end	Center	Side end	Center	Side end	
	Inside	Outside	Outside	Inside	Outside	Inside	Outside	
Bending moment M (kNm)	5.628	27.967	23.851	24.541	23.550	27.866	27.460	
Axial force N (kN)	88.083	94.882	81.101	42.081	42.081	52.419	52.419	
Shearing force S (kN)	-	41.231	35.989	-	58.887	-	67.746	
Height of member h (m)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	
Effective height d (m)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
Bar arrangement	D16@200	D16@200	D16@200	D16@200	D16@200	D16@200	D16@200	
Compressive stre σc (N/mm^2)	0.65	4.60	3.92	4.27	4.09	4.81	4.75	
(Allowable value) σca (N/mm^2)	9.5	9.5	9.5	9.5	9.5	9.5	9.5	
Tensile stress σs (N/mm^2)	1.87	91.89	78.26	103.12	98.01	110.40	112.43	
(Allowable value) σsa (N/mm^2)	200	200	200	200	200	200	200	
Shearing stress τ (N/mm^2)	-	0.21	0.18	-	0.29	-	0.34	
(Allowable value) τa (N/mm^2)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
Judgement	OK	OK	OK	OK	OK	OK	OK	

18. Operation and Maintenance of Regulators

18-1 Water utilization management

It is desirable to conduct the water management of the group of regulator through developing an annual irrigation plan based on the farming plan of the beneficiary area such as the type of crops, acreage area and cropping time, closely cooperating with the administrators or related organizations.

Actual gate operation shall be controlled so that a predetermined flow rate is discharged according to the fluctuation of the water level in the upstream and downstream within the range of the design hydraulic condition of the regulators in the table below.

Table 18-1.1 Operational condition of gates

Name of regulator	Name of canal	Design max. discharge (m^3/s)	Design U/S high water level(m)	Design U/S low water level(m)	Design D/S high water level(m)
Bahr Yusef		227.0	46.30	45.90	45.82
Ibrahimia		186.0	46.30	45.90	45.13
Badraman	Badraman	9.0	46.30	45.90	45.90
	Diroutiah	12.0	46.30	45.90	45.90
AboGabal	AboGabal	7.0	46.30	45.90	45.90
	Irad Delgaw	9.0	46.30	45.90	45.90
Sahelyia		5.0	46.30	45.90	45.90

As an example, when the upstream water level is constant, the gate opening degree (assumed to be operated at the same opening degree at all gates) necessary for discharging the design maximum flow rate due to the change of the downstream water level was calculated.

The gate operation in discharging should be careful not to cause significant water level fluctuation in the downstream channel as much as possible, and to prevent scouring of river bank or bed protection due to leaning of streamline to one side, opening order and opening degree by one operation should be noted.

Table 18-1.2 Trial calculation result of gate openings at each downstream water level

Name	Discharge (m^3/s)	Width (m)	Qunatity	Gate sill elevation (m)	U/S water level (m)	U/S water height (m)	D/S water level (m)	D/S water height (m)	Gate openings (m)	Outflow form
Bahr Yusef	227.0	6.00	4	40.00	46.30	6.30	45.82	5.82	3.45	Submerged
							45.60	5.60	2.99	Submerged
							45.40	5.40	2.71	Submerged
							45.20	5.20	2.48	Submerged
							45.00	5.00	2.30	Submerged
Ibrahimia	186.0	6.00	4	40.00	46.30	6.30	45.13	5.13	2.09	Submerged
							44.80	4.80	1.86	Submerged
							44.60	4.60	1.75	Submerged
							44.40	4.40	1.65	Submerged
							44.20	4.20	1.55	Submerged
Badraman	9.0	2.00	2	43.90	46.30	2.40	45.90	2.00	0.97	Submerged
							45.60	1.70	0.74	Submerged
							45.30	1.40	0.60	Free flow
Diroutiah	12.0	2.00	3	44.20	46.30	2.10	45.90	1.70	0.85	Submerged
							45.30	1.10	0.57	Free flow
AboGabal	7.0	2.00	2	43.60	46.30	2.70	45.90	2.30	0.84	Submerged
							45.60	2.00	0.65	Submerged
							45.00	1.40	0.43	Free flow
Irad Delgaw	9.0	2.00	2	43.60	46.30	2.70	45.90	2.30	1.02	Submerged
							45.60	2.00	0.78	Submerged
							45.00	1.40	0.56	Free flow
Sahelyia	5.0	2.00	2	43.00	46.30	3.30	45.90	2.90	0.66	Submerged
							45.60	2.60	0.51	Submerged
							45.00	2.00	0.37	Submerged

18-2 Maintenance of civil engineering structures and buildings

In order to secure the function of the facility for the long term in the future, it is important to properly monitor and repair the condition. Recommended inspection content and frequency are shown below.

(1) Inspection

Periodic inspection is to monitor the presence of change in the state of the facility and the extent and transition of it if there is any change. It is desirable to conduct it once a month by visual observation or measurement using observation equipment. Inspection of apron which is always submerged is basically done during the annual winter closure period, the results of inspection should be recorded and kept to utilize it.

In general, changes often occur at the junction point of the structure, the change point of the section and the end of the revetment work, careful attention should be paid to the following events, especially.

1) Deformation

Settlement of pier ,weir body, base slab and apron

2) Abrasion

State of development of abrasion at the weir body, base slab and apron

3) Cracks on the concrete surface

Presence of cracks and their development at the weir body, base slab and apron

4) Leakage

Presence of water leakage and its amount changes from concrete joint and apron tip, etc.

5) Scouring

Presence of scouring and its development at the river bed protection and apron

6) Obstacles

Presence of sediments, driftwoods and other obstacles which disturb proper operation

(2) Maintenance

If some defects are found as a result of inspection, conduct detailed investigation as necessary to clarify the cause and the necessity of repair. When it is judged that repair is necessary, the repair work is carried out after studying the repair method and timing according to the damage degree of the structure.

18-3 Maintenance of equipment

Since equipment items such as observation equipment, mechanical equipment and electric equipment greatly influence the function and its maintenance of regulators combined with the civil engineering structure, it is necessary to implement appropriate management systematically. The flow of maintenance and management of gate facilities generally repeats the cycle of inspection, maintenance and actual operation. When aged deterioration advances, repair of equipment and updating of devices are carried out as necessary .

(1) Inspection

Inspection is a task of finding defects or damage of facilities, judging whether they function well or not. It is necessary to conduct comprehensive inspection as a system as a whole facility including a remote operation systematically.

Table 18-3.1 Inspection classes and cycle

Class	Cycle	Contents of inspection
Inspection on operation	Every operation time	It checks the presence of trouble at start of operation for discharge or intake, the situation such as presence of defects and change at the time of operation and the end of operation. In principle these are carried out every operation time.
Daily inspection	Everyday or less than one month	To maintain the equipment in a state to operate properly all the time, confirm the operation status of each equipment, breakage, looseness of bolts and nuts by visual inspection, touch examination and test hammer focusing on damage detection at the initial stage.
Periodic inspection	Every three or six months or every few years	Detailed inspection and measurement of each part is carried out by expert engineers, and slight maintenance such as refueling of each part and replacement of parts may also be carried out in some cases.

(2) Maintenance

Maintenance is a work such as parts replacement or repair to respond to failures, damage, fatigue, deterioration of facilities and equipment, to prevent these or to maintain the function of facilities based on the judgment result of inspection. Regular maintenance is mainly carried out using tools, machinery and equipment. Main maintenance contents and recommended cycle for large scale regulators (hydraulic cylinder type roller gate) and small scale regulators (electric rack type slide gate) are shown in the following table.

Table 18-3.2 Contents and cycle of maintenance

Cycle	Items		Contents of maintenance
	Classification	Target facility	
Three years	Hoist	Small regulators	Replace of grease for rack or spindle shaft
		All regulators	Replace of grease for shaft coupling
Five years	Gate leaf	Large regulators	Replace of grease for oil supply device and overhaul
	Hoist	Large regulators	Overhaul and inspection of hydraulic unit components Replacement of hydraulic oil and cleaning of oil tank
		Small regulators	Overhaul and inspection of hoisting equipment Lubrication of reduction gear
Ten years	Gate leaf	Large regulators	Overhaul and inspection of roller and sheave
		All regulators	Repainting（8 to 10 years interval） Replacement of seal rubber (10 to15 years interval)
	Hoist	Large regulators	Overhaul and inspection of hydraulic unit components Overhaul and inspection of hydraulic cylinder
		Small regulators	Overhaul and inspection of hoisting equipment
		All regulators	Overhaul and inspection of shaft coupling, bearing and opening indicator

Note) Ten years cycle maintenance is carried out including the contents of five years cycle maintenance work.

(3) Method to remove gate leaf

The upper part gate guide of small scale regulators can be removed so that replacement of seal rubber and inspection and maintenance of side part of gate leaf in the future can be carried out by taking out the gate.

Since the gate pier of large scale regulators consists of four separated columns, inspection and maintenance of the end part of the gate such as the main roller can be performed with the gate leaf lifted. When there is a necessity for equipment renewal or large-scale repair in the future, remove from the top slab using a large crane in the order of the hydraulic cylinder, base frame and the gate leaf.

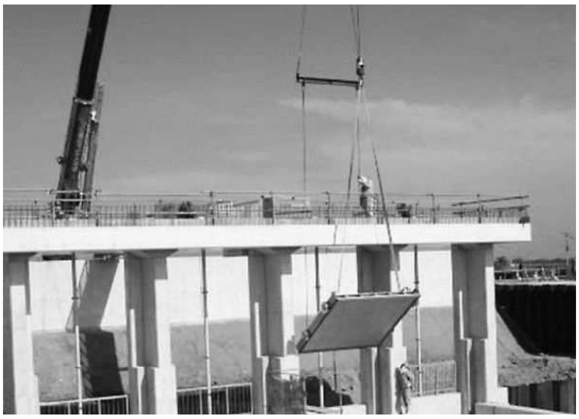


Figure 18-3.1 Hanging method of gate (Small regulators)

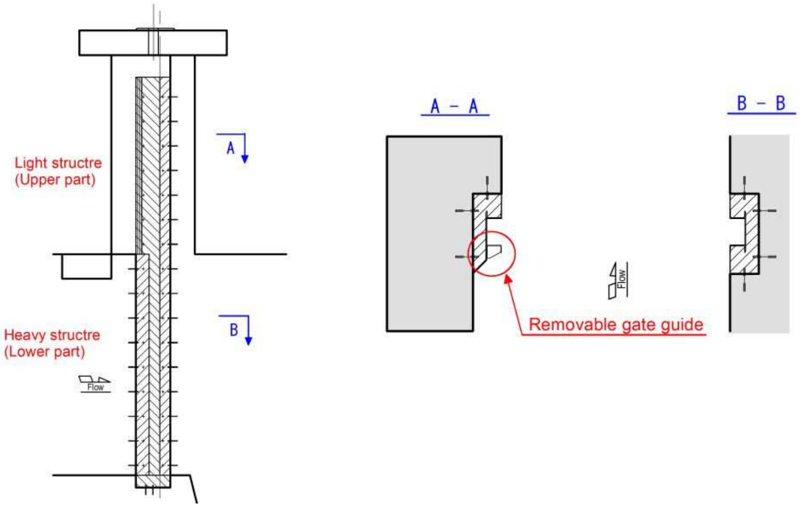


Figure 18-3.2 Structure of gate guide of small scale regulators

(4) Record of maintenance

In order to inspect and maintain the equipment, it is necessary to understand the structural features, dimensions, specifications, handling method and judge the state. For that purpose, it is important to keep the completion documents and instruction manuals of equipment to utilize at any time. In addition, records of inspection and maintenance should be used not only as a record of them but also as materials for understanding the deterioration status with age and for long-term maintenance plan of the facility based on the future change prediction. Therefore, it is desirable to create a database and store the recored using electronic media so that the history of inspection and maintenance can be utilized for a long time.

Table 18-3.3 Recommended storage period of maintenance record

Item	Classification	Period	Remarks
Completion documents	New and renewal	Permanent	Specification, design calculation, drawing, construction management record, etc.
Construction photos		Permanent	During and completion of construction
Inspection record	Daily inspection	1 year	
	Inspection on operation	3 years	
	Periodic inspection	5 years	
Maintenance record	Maintenance record	Permanent	
	Periodic maintenance	5 years	
Operation record	Operation record	Permanent	Unusual state should be noted
	Failure record	Permanent	

18-4 Management of target canal bed elevation

Around DGRs, the removal of sedimentation in the canal is carried out in January by stopping the intake from upstream, which is called “Winter Closure” period and usually takes several weeks in every January. After completion of the construction of NDGRs, fluctuations of the canal bed elevation due to sediment deposition and scouring are expected including the area between DGRs and NDGRs. Since the excessive change in the canal bed height may affect the stability of the regulators' body, the connecting bank protection works ,and the smooth gate operation as well, appropriate management is required. The basic management policy during the construction period and the future period is described below.

(1) During the construction of the NDGRs

The NDGRs is planned to be constructed in the temporary cofferdam using steel sheet piles. Since the cofferdam is designed to be stable under the current ground level condition based on the survey result, dredging works around the sheet pile area should be avoided. The design ground height of double steel sheet pile is designed as follows.

Table 18-4.1 Design bed elevation for cofferdam works

Location	Design bed level of double sheet pile works
Bahr Yusef regulator	EL 39.00m
Ibrahimia regulator	EL 39.00m
Abo Gabal regulator	EL 43.00m
Sahelyia regulator	EL 43.00m

(2) Beginning of the first operation of NDGRs and their future maintenance

The sediment in front of the gates can be removed by gate operation if it is less than a certain amount, but the sediment remaining on the gate sill may have a negative impact to the gate closing operation. Therefore, it is desirable to grasp and manage the sedimentation condition once a year so that the bed height around the regulators is kept below the gate sill height. On the other hand, if the canal bed elevation becomes significantly lower due to excessive dredging, the stability of the regulators and the connecting bank protection works of steel sheet piles is badly affected. For this reason, it is necessary to control the canal bed level within the range of elevation shown in the table below on the basis of the height of the regulators and the design bed elevation of the bank protection works.

Table 18-4.2 Management of canal bed elevation after the construction of NDGRs

Location	EL.(A) (m)	EL.(B) (m)	EL.(C) (m)	EL.(D) (m)	Management level	
					Highest (m)	Lowest (m)
Ibrahimia regulator	40.00	39.50	36.50	39.50	40.00	39.50
Abo Gabal regulator	43.60	42.75	40.25	42.60	43.60	42.60
Sahelyia regulator	43.00	41.55	39.05	41.55	43.00	41.55

Note: EL.(A);Gate sill elevation
EL.(D); Design bed elevation of bank protection works

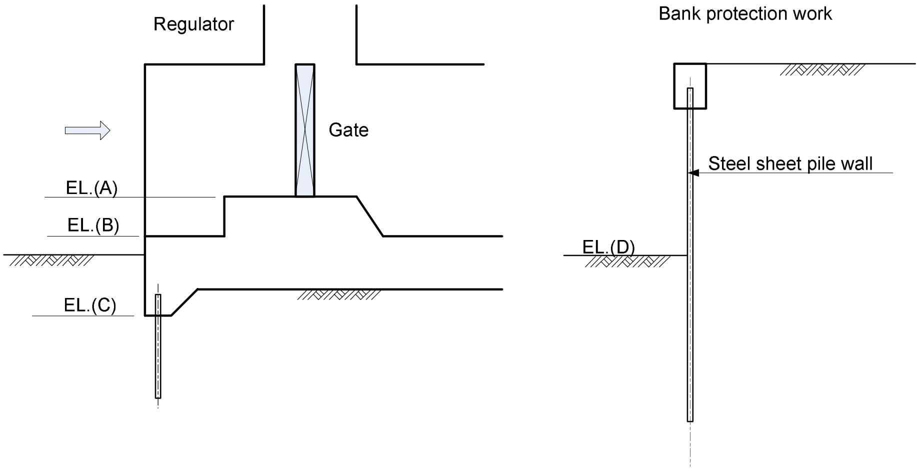


Figure 18-4.1 Explanatory drawings for EL.(A) to EL.(D)

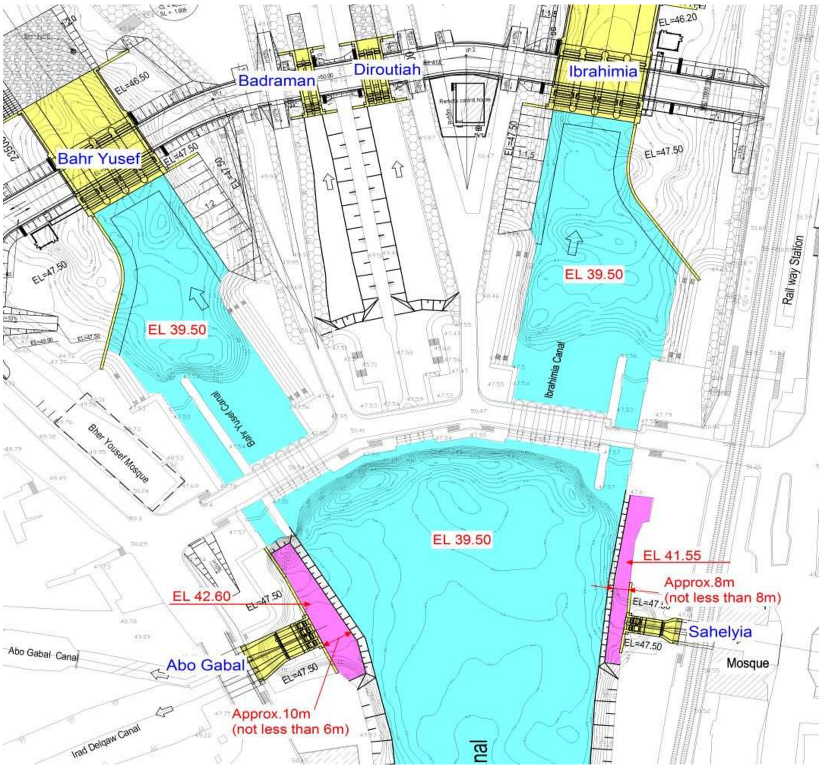


Figure 18-4.2 Canal bed elevation around the regulators

19. Examination of the Preservation Measures for Existing DGRs

19-1 Prerequisites for examination of preservation measures

The existing DGRs is the irrigation water supply facility having been in use for 145 years since its construction in 1872. As shown in Table 19-1.1, its year of construction is a long time ago even in Egypt, but it is still in active operation while rehabilitation and partial renewal works have been made.

In the construction project for the DGRs that will be implemented for the purpose of sustainable acquisition and supply of water resources to enhance the agriculture in Upper Egypt, the function of the existing DGRs as the regulator will be removed.

However, given that the existing DGRs has been the long time, the Egyptian government has decided that they should be preserved as a historical monument with a function of bridge.

In this chapter, the necessary and reasonable works of the rehabilitation and reinforcement for the preservation of the existing DGRs are suggested based on the results of the past surveys.

Table 19-1.1 History of rehabilitation and partial renewal of DGRs

1870	1872	Construction of the regulators was completed		1861:Delta Barrage
1880			1881	
1890			Silt clear lance (Canal dredging)	
1900	1900 1907	Remodeling work		1902:Aswan Dam Asyut Brrage Zefta Brrage 1906:Esna Barrage
1910	1910 1911	Foundation Treatment (Cement grouting)	1912	
1920				
1930	1935	Abo Gabal intake regulator was constructed		1930:Naga Hammady Barrage 1935:(Delta Barrage)
1940				
1950				
1960	1962	Improvement work ・Extension of apron of Ibrahimia ・Driven wooden sheet pile ・Protection of the canal bed		
1970				1971:High Aswan Dam
1980				1994:(Esna Barrage)
1990			Canal dredging	
2000	2001	Maintenance of regulator (Gates,Chains,etc.)		2008:(Naga Hammady Barrage)
2010				
2020	2022	【NDGRs】 Completion of the construction		

As the prerequisites for the suggestions on the necessary and reasonable works, the following purposes were confirmed by the Design WG on 9th February, 2017:

- To preserve the existing DGRs as a historical monument.
- To remove the practical functions of regulators by the removal of the gates or keeping the gates open completely.
- To remain the bridge function with some traffic restrictions for large and heavy vehicles.

19-2 Survey results

(1) Survey results in the past years

The results of the survey on the existing DGRs were reported in the "*Preparatory survey for the rehabilitation and implement of Dirout Group of Regulators, October 2010*". The summary of the survey is shown in Table 19-2.1. The items of the surveys are as follows:

- Visual survey
- Diving survey (photography by waterproof camera)
- Unconfined compression test (regulator surface and in the body)
- Permeability test in regulator body
- Boring survey in regulator body

Table 19-2.1 Results of past surveys (1/3)

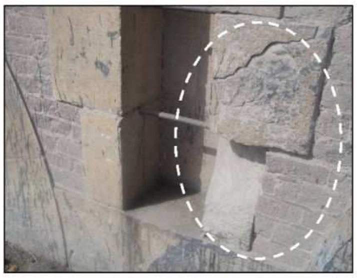
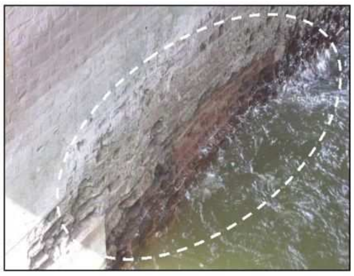
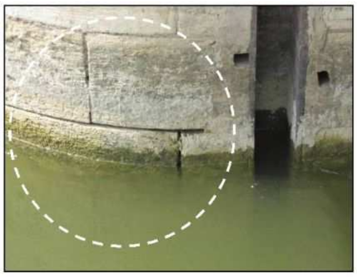
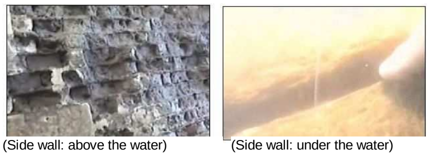
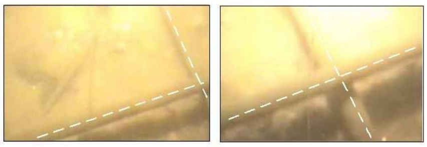
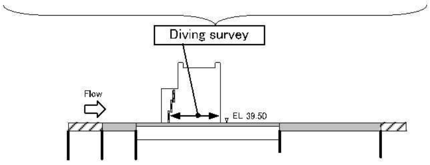
Name of Survey	Survey Results	Remarks
Visual Survey	・ Chips of bricks and stones in a small range, and cracks of up to 2 mm in bricks were confirmed above the water surface. These deteriorations were not caused by the long-time stress impacts, but it is considered that they were the damage by temporary impacts and defects in the initial construction stage. (See Photo-1.) ・ Below the water surface, it was found that bricks had fallen out from the sides of the Ibrahimia regulator directly under the gate. In particular, substantial wear of about 30 cm (eye-estimation) was visually checked on the side of the regulator on the right bank of the Ibrahimia Regulator. The bricks themselves may have been worn and deteriorated during aging degradation, but the mortar surrounding bricks worn first and lost; this caused missing fallen out bricks in large area and repeated afterwards. Therefore, it is of concern that the wearing will be accelerated and expand in future. (See Photo-2.) ・ The regulator piers on the upstream side of the Ibrahimia, Badraman and Bahr Yusef regulators are protected by stone materials, but the ancient mortar made by finely smashing limestones and kneading the fine sand with water was used, is different from the present-day mortar. It was found that these mortar parts had fallen out or washout. Especially, on around the water surface, the mortar is susceptible to the washout due to the up and down movements of the water surface. The peel-off depth is unclear, but there is concern that the peel-off of mortar parts may cause the collapse of the regulator piers. (See Photo-3.)	 Photo-1 Ibrahimia regulator  Photo-2 6th gate from the right bank of the Ibrahimia regulator  Photo-3 Bahr Yusef regulator
Diving Survey	The diving survey (underwater camera photography) was made in the 2nd vent on the right bank of the Bahr Yusef regulator (Figure 1) and in the 5th vent on the right bank of the Ibrahimia regulator (for the days of January 2 to 4, 2010). ・ The mortar parts to join the bricks and stone materials eroded in the Bahr Yusef and the Ibrahimia regulators. There is concern that such loss of the mortar parts may weaken the integrity of the structure and expand the erosion of the bricks and stone materials. ・ Concrete was placed on the apron surfaces of the Bahr Yusef and Ibrahimia regulators in the rehabilitation work in 1962. The concrete parts were worn down and had been eroded away. In particular, it was found that only reinforcement bars remained in the Bahr Yusef regulator, having no rehabilitation effect at that time.	 (Side wall: above the water) Scouring and lost of brick are severe (Side wall: under the water) Mortar between the brick has lost  (Surface of apron) Concrete has scoured, only the re-bars remain. (Surface of apron) Concrete has scoured, only the re-bars remain  Figure 1. The result of diving survey on the Bahr Yusef regulator

Table 19-2.2 Results of past surveys (2/3)

<table>
<tr><th>Name of Survey</th><th>Survey Results</th><th>Remarks</th></tr>
<tr><td>**Diving Survey**</td><td>

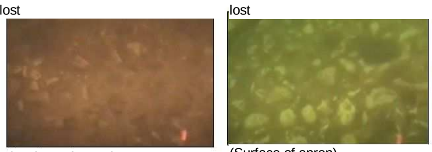
In the Ibrahimia regulator, the aggregates in the concrete were significantly exposed (10 cm to 20 cm) and the concrete thickness at the time of rehabilitation work was not kept. The placed concrete thickness of the aprons of the both regulators as checked in the drawing was about 25 cm in the Bahr Yusef canal and about 55 cm in the Ibrahimia canal.

From the above survey results, it is supposed that the rehabilitation of the aprons at that time was the apron reinforcement/expansion work associated with the upstream water level raised in the DGRs. It is confirmed that the reinforcement work for the aprons directly under the gates has almost lost the initial thickness. Therefore, the future acceleration of wear is of concern.

</td><td>

(Sidewall: under the water) Mortar between the bricks has been lost

(Sidewall: under the water) Mortar between the bricks has been lost



(Surface of apron) Aggregates appear because of concrete abrasion

(Surface of apron) Aggregates appear because of concrete abrasion

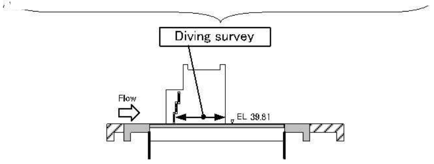


Figure 2. The result of diving survey on the Ibrahimia regulator

</td></tr>
<tr><td>**Unconfined compression Test**</td><td>

● Unconfined strength of regulator surface

From the results of the unconfined compression strength test on the cores sampled from the depth of about 50 cm under the regulator surface, it was found that the cores were lower than the endurance strength of 70 kg/cm^2 to 80 kg/cm^2 required strength of brick in Egypt (*Egyptian Code for the Design and Implementation of brick and buildings ECP 204-2005*).
Brick construction technology in Egypt had a long history and it is imagined that the construction technology similar to that of the present time was used in the past. Therefore, it is supposed that the regulator surface layer was under the weathering impact of the open air for a long period, resulting in the lower strength. This should be considered if the existing regulators are kept in continuous use by rehabilitation. The unconfined compression strength of each regulator is shown in Table 1.

● Unconfined compression strength of regulator depth

The unconfined compression strength tests of the foundation depths of the existing DGRs were conducted by the Water Research Center, Construction Research Institute at the time of this Study (2009) and in 2006. These unconfined test results are summarized in Table 2 and Table 3.

</td><td>

Table 1. Unconfined compression strength of regulator surface layers

Regulator	Test Value (kg/cm^2)	Standard Value (kg/cm^2)
Bahr Yusef	21	70～80
Ibrahimia	24	
Badraman	13,7	

Table 2. Unconfined compression strength of regulator pier depths

Regulator	Average Test Value in 2006 (kg/cm^2)	Average Test Value in 2009 (kg/cm^2)
Bahr Yusef	38.2	26.1
Ibrahimia	38.9	26.3
Badraman	38.7	10.0

Table 3. Unconfined compression strength of regulator foundation depths

Regulator	Average Test Value in 2006 (kg/cm^2)	Average Test Value in 2009 (kg/cm^2)
Bahr Yusef	40.7	80.3
Ibrahimia	39.6	72.3
Badraman	―	―

</td></tr>
</table>

Table 19-2.3 Results of past surveys (3/3)

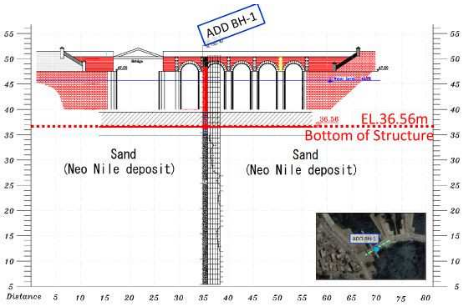
<table>
<tr><th>Name of Survey</th><th>Survey Results</th><th>Remarks</th></tr>
<tr><td>Permeability Test in the Regulators</td><td>The permeability test in the regulators was also conducted by the CRI, NWRC in 2006. These test results are summarized in Table-4.
According to the existing literature, the permeability value of general bricks is 10^{-6} cm/sec (E-06). In comparison with this value, it is confirmed that the permeability values of the existing DGRs are from 10 to 100 times higher.
In the tendency of the above permeability values, especially, the values of regulator piers are 1.2 to 1.6 times higher than the foundations. This means that the regulator piers are susceptible to the dryness and wetness due to water level variations. Further, it seems that the brick materials with high permeability increase the water absorption, facilitating the deterioration of the regulator piers. The tendency of deterioration coincides with the strength values in the unconfined compression test. The deterioration of bricks of the regulator piers and the reduction of adhesiveness of the mortar are of serious concern.</td><td>Table 4. Permeability test in regulators
<table>
<tr><th>Regulator</th><th>Position</th><th>Average Permeability Value in 2006 (cm/s)</th><th>Average Permeability Value in 2009 (cm/s)</th></tr>
<tr><td>Bahr Yusef</td><td>Pier</td><td></td><td>1.01E-04</td></tr>
<tr><td></td><td>Foundation</td><td>7.25E-05</td><td>8.43E-05</td></tr>
<tr><td>Ibrahimia</td><td>Pier</td><td></td><td>1.13E-04</td></tr>
<tr><td></td><td>Foundation</td><td></td><td>1.12E-04</td></tr>
</table></td></tr>
<tr><td>Boring Survey in the Regulators</td><td>The boring surveys in the regulators were made to assess the detailed deterioration and the foundation conditions within the Bahr Yusef and the Ibrahimia regulators (in December 2009).
● The deterioration conditions in the regulators are shown in the results of unconfined compression and permeability tests in the regulators.
● The clear traces of the grouting works which were done from 1900 to 1911 as reported could not be identified. It was observed that medium sand with N-value of 13 to 15 is identified under the foundations of the Bahr Yusef regulator, and that the foundation ground was weaker than that in the Ibrahimia regulator. (See Figure 3 and Figure 4.)</td><td>

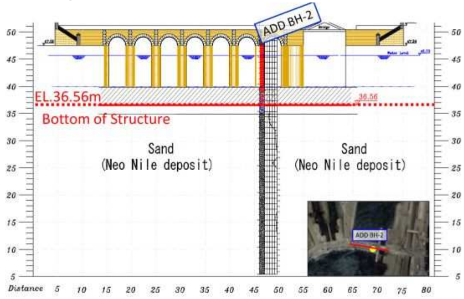
Figure 3. The result of the boring survey on the Bahr Yusef Regulator


Figure 4. The result of the boring survey on the Ibrahimia Regulator</td></tr>
</table>

(2) Available materials and works for the preservation

In order to the consider the prevailing works and methods for the preservation as historical monument in Egypt, the field survey on the Delta Barrage with the related agencies in RGBS was conducted. In the Study, the actual works and the applied materials for the preservation works were studied through the visual survey and the interview to the persons responsible at the site. The results of the field survey in the Delta Barrage are shown in Table 19-2.4, and the materials (photos) of the actual preservation measures are identified in Table 19-2.5 and Table 19-2.6.

Table 19-2.4 Field survey results in the Delta Barrage

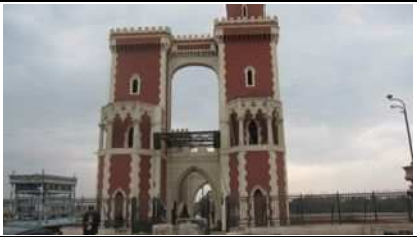
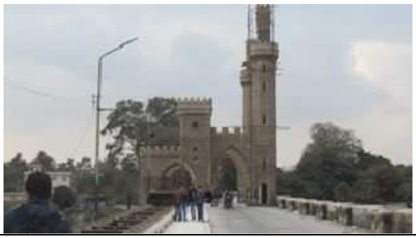
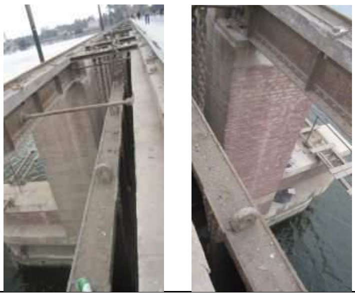
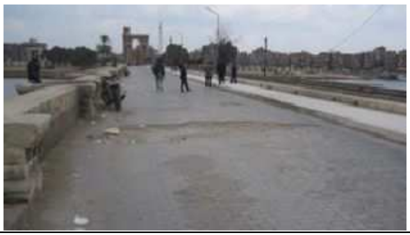
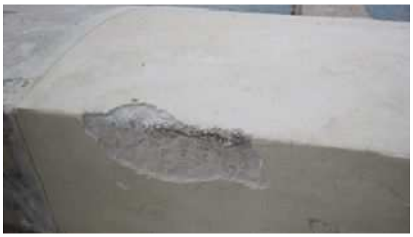
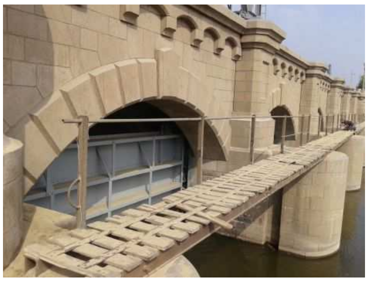
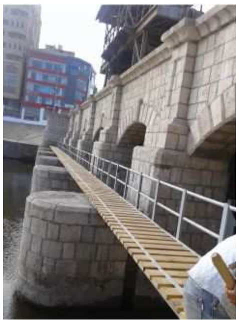
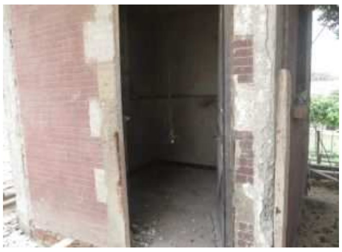
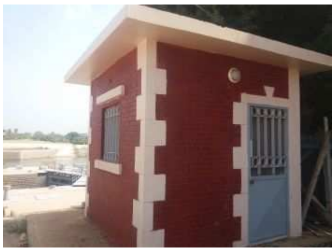
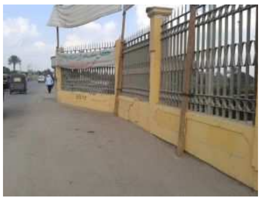
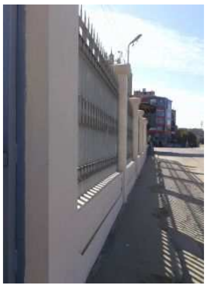
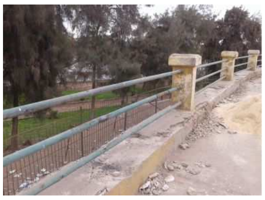
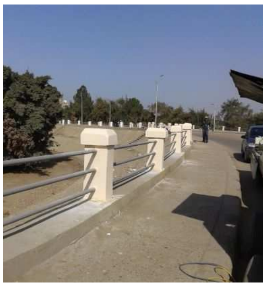
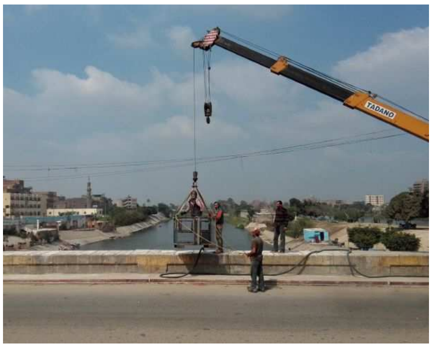
<table>
<tr><td colspan="3">The old Delta Barrage is under the rehabilitation work by Ministry of Antiquities at present.
After the new Delta Barrage built in 1939, the function as a regulator was removed and the passage on of the regulator has been limited to pedestrians, bicycles and motorbikes. The staffs in charge of the regulator administration are stationed at the entrance of the regulator.</td></tr>
<tr><td colspan="3">Photos in Field Survey</td></tr>
<tr><td>1</td><td></td><td>Entrance tower on the east side of the barrage
The fences and stone blocks to prevent large size traffic are installed.
The surface of the gate tower was restored.</td></tr>
<tr><td>2</td><td></td><td>Entrance tower on the west side of the barrage.
The surface of structure has not been restored.</td></tr>
<tr><td>3</td><td></td><td>All the gates are kept fully open. The hoisting device remains at the site.
The surfaces of the barrage piers are covered with mortar in the same color as the bricks.</td></tr>
<tr><td>4</td><td></td><td>Some damages were observed on the road of the bridge, which seems to be caused by the past passage of vehicles.</td></tr>
<tr><td>5</td><td></td><td>A part of mortar on the rehabilitated handrails was damaged and peeled off.
According to the staff, about 10 years has passed since the latest rehabilitation. Such works were regularly done.</td></tr>
</table>

Table 19-2.5 Photos of preservation measure cases (1/2)

No.	Photos of Preservation Measure Cases
1	**Gate Repair** (Before rehabilitation) (After rehabilitation)
2	**Rehabilitation of Bank Protection Works** (Before rehabilitation) (After rehabilitation)
3	**Rehabilitation of Steel Bridge** (Before rehabilitation) (After rehabilitation)
4	**Rehabilitaton of Hoisting Device** (Before rehabilitation) (After rehabilitation)

Table 19-2.6 Photos of preservation measure cases (2/2)

No.	Photos of Preservation Measure Cases
5	**Rehabilitation of Maintenance bridge**  (Before rehabilitation)  (After rehabilitation)
6	**Rehabilitation of Gate Operation Room**  (Before rehabilitation)  (After rehabilitation)
7	**Rehabilitation of Fences and Handrail**  (Before rehabilitation)  (After rehabilitation)  (Before rehabilitation)  (After rehabilitation)
8	**Others** (Coating of lighting pole)  (Gondola for inspection and rehabilitation)

19-3 Recommendations for preservation measures

(1) Suggestion of evaluation method

In the preservation measures for the existing DGRs, it is recommended to make the examination in accordance with the following flow chart in considering the following points:

1. The function of the regulator is removed, that is, the gate operation for appropriate water distribution by the existing DGRs is never considered. Therefore, the up-lift pressure caused by the water level difference and the local impact of high flow velocity are substantially alleviated and the high-water level (Approx. WL.46.30 m) is kept even on the downstream side of the existing gates.
2. The traffic of large vehicles is limited on the ancillary bridge, which alleviates the traffic loads on the regulators.
3. The consideration for the landscape is required to preserve the DGRs as a historical monument

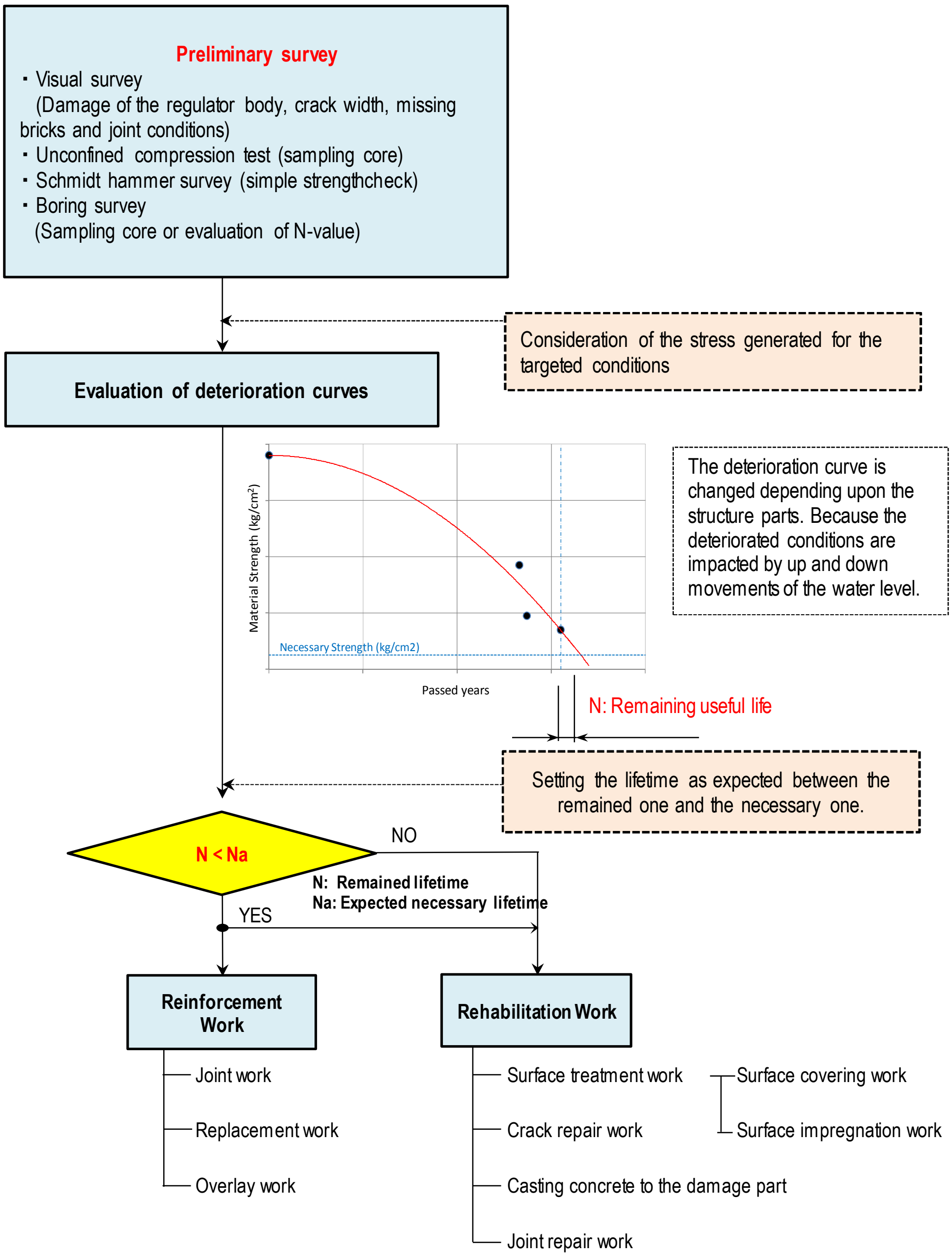
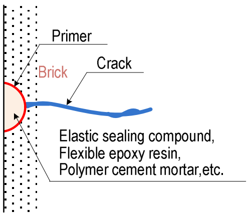
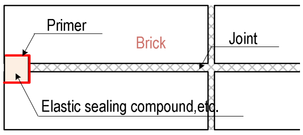

Preliminary survey
・Visual survey
(Damage of the regulator body, crack width, missing bricks and joint conditions)
・Unconfined compression test (sampling core)
・Schmidt hammer survey (simple strengthcheck)
・Boring survey
(Sampling core or evaluation of N-value)
Consideration of the stress generated for the targeted conditions
Evaluation of deterioration curves
Material Strength (kg/cm²)
Necessary Strength (kg/cm2)
Passed years
The deterioration curve is changed depending upon the structure parts. Because the deteriorated conditions are impacted by up and down movements of the water level.
N: Remaining useful life
Setting the lifetime as expected between the remained one and the necessary one.
N < Na
NO
YES
N: Remained lifetime
Na: Expected necessary lifetime
Reinforcement Work
Joint work
Replacement work
Overlay work
Rehabilitation Work
Surface treatment work
Surface covering work
Surface impregnation work
Crack repair work
Casting concrete to the damage part
Joint repair work

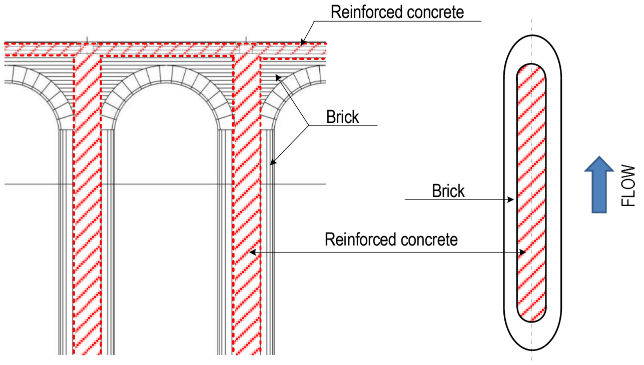
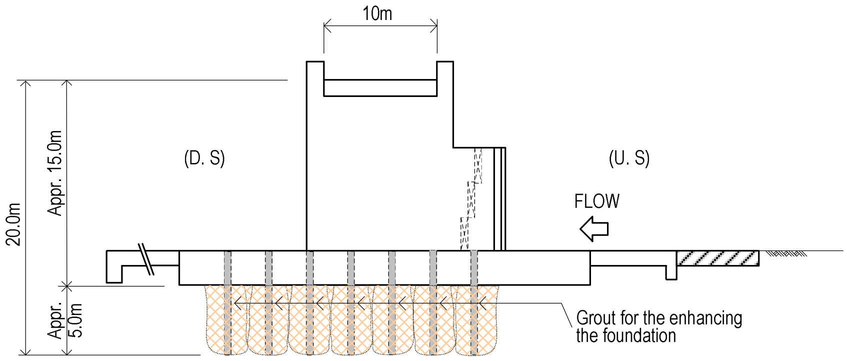
Figure 19-3.1 Flow of examination of appropriate measure works

Note : The deterioration curve is cited from the “*Preparatory survey for the rehabilitation and implement of Dirout Group of Regulators, October 2010*”. The curves can be updated by the recent investigated data if the new survey is conducted.

In examining the preservation measures of the existing DGRs, the effective measures as shown in Table 19-3.1 are recommended based on the prerequisites as mentioned in the beginning and the past survey. For the appropriate preservation measures, it should be taken into consideration the economic aspects, constructability, reliability and sustainability of the measures based on the detailed survey and careful consideration.

Table 19-3.1 Recommendations for preservation measures for DGRs

Preservation works		**Detailed contents of the works**	**Problems and Remarks**
Change of function	✓**Preservation of gates**	➢ The gate doors are fixed in the fully opened and preserved at the present positions. The same measures are applied to the hoists.	For the preservation, the study on the necessity of rehabilitation works (such as coating) should be required.
	✓**Traffic limitation of vehicles**	➢ The traffic limited to the pedestrians, bicycles and motorbikes, which the same as the Delta Barrage. ➢ Therefore, the parking blocks (stones) are stationed on the exits and entrances on the left and right banks of the ancillary bridge.	The measure will be implemented after the construction of the NDGRs.
Rehabilitation works	✓**Repair of cracks** ✓**Repair of joints between the main parts**	➢ The deterioration of the bricks used in the regulators is caused by repeated drying and wetting of cracks and joints (mortar). ➢ In order to prevent the more deterioration, it is essential to repair the cracks and joints before the expanding width or the gaps. ➢ The materials for the repair of cracks and joints should have excellent property in adhesiveness, flexibility and abrasion resistance as well as weather resistance and visual matching.  Primer Brick Crack Elastic sealing compound, Flexible epoxy resin, Polymer cement mortar,etc. Repair of cracks  Repair of joints	If there are many cracks and damaged joints, it can be also necessary to apply the surface treatment or surface impregnation method for the impact of the drying and wetting into the regulators body.
	✓**Casting concrete to the damaged part**	➢ The parts where bricks fallen out are repaired with the materials without the visual gaps ➢ The exposed iron bars of the aprons that were confirmed by the diving survey should be repaired by covering the concrete. After the construction of the NDGRs, the present high flow velocity will not be caused, but joint bars between the original aprons will be installed to secure the stable concrete casting.	There is an idea to preserve the regulators as a historical monument including the present (decayed) state. Therefore, it is necessary to review before the rehabilitation of the damaged parts in this aspect.

Reinforcement works	✓**Replacing to the enhanced structure**	➢ If any reinforcing and enhancing work is required to the structure, the following method is recommended. This work requires much time and cost. ➢ A reinforced concrete pier is constructed in the regulator body of 1.85 meter wide to concentrate the tensional load into the reinforced concrete pier. As a result, only the compressive load by bricks own weight acts to them.  Reinforced concrete Brick Brick Reinforced concrete FLOW	It is necessary to check the structural stress by the detailed analysis (such as 3D finite element method). In the construction work, it is necessary to examine the impacts (by such as vibrations) on the existing brick pieces.
Others		➢ If any void area are observed in the foundation by the boring survey, those void are filled and injected with grout materials. ➢ The reasonable number of the grout and the grouting pressure are subject to the foundation conditions and structure strength.  10m (D. S) (U. S) FLOW 20.0m Appr. 15.0m Appr. 5.0m Grout for the enhancing the foundation	The stress check is necessary to compare between the brick strength and the pressure stress by the grouting.

(2) Recommendation

Based on the present available data (2010), the following survey and the essential works are recommendable.

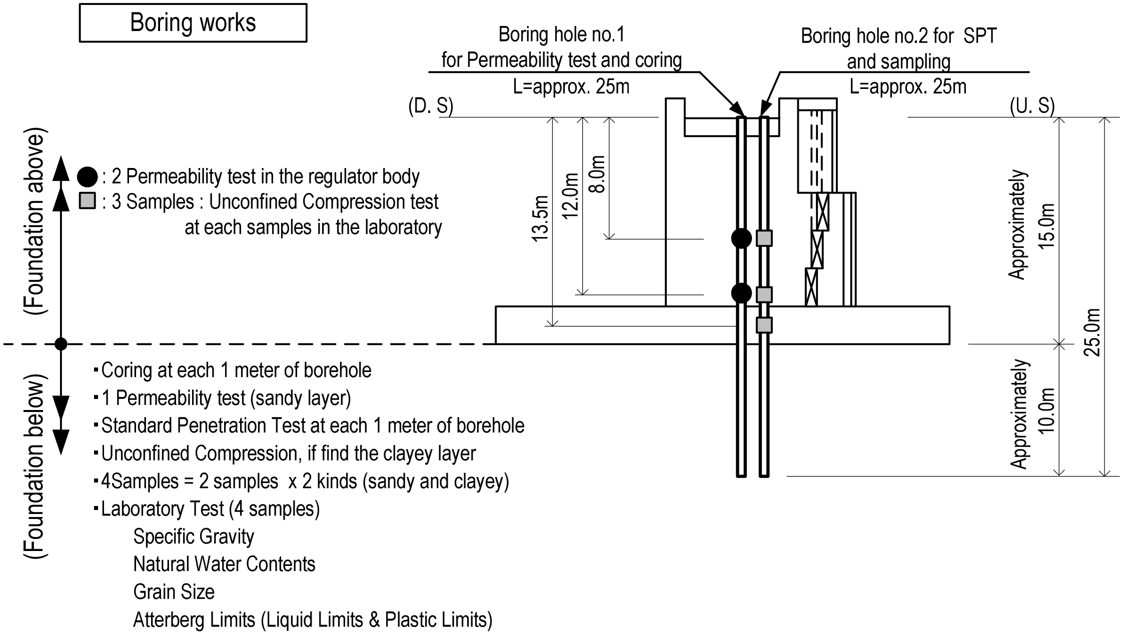
Recommendable survey

- ✓ To study and check the exact present status of the existing DGRs, two boring survey for each pier should be conducted. The unconfined test and the permeability test should be conducted for the sample cores taken from the boreholes.
- ✓ The investigated data should be compared to the past survey data. The data could be useful for

updating the deterioration curve to evaluate the structural life time remained.

- ✓ 3D finite element analysis could be useful for the entire evaluation of the present status of the existing DGRs. For the analysis, it is recommendable to take the support of organization that has the enough experience for the existing DGRs is recommendable (for example, CRI has the experience of the analysis for DGRs in 2006).

Table 19-3.2 Recommendable survey

Survey items	Contents
Visual check to the existing DGRs	・The visual survey should conduct during the winter closure which season is from December to January. ・Especially, the invisible place i.g., the apron and the edge of pier due to the under the water, should be careful investigated.
Boring survey	・Two borehole in one pier are necessary. One hole is for the permeability test and coring, the other is for the SPT and the sampling for the laboratory test. ・Inner diameter of borehole shall not be less than 86mm ・The following picture is shown the boring plan  Boring works Boring hole no.1 for Permeability test and coring L=approx. 25m Boring hole no.2 for SPT and sampling L=approx. 25m (D. S) (U. S) (Foundation above) ●: 2 Permeability test in the regulator body ▨: 3 Samples : Unconfined Compression test at each samples in the laboratory 13.5m 12.0m 8.0m Approximately 15.0m 25.0m Approximately 10.0m (Foundation below) ・Coring at each 1 meter of borehole ・1 Permeability test (sandy layer) ・Standard Penetration Test at each 1 meter of borehole ・Unconfined Compression, if find the clayey layer ・4Samples = 2 samples x 2 kinds (sandy and clayey) ・Laboratory Test (4 samples) Specific Gravity Natural Water Contents Grain Size Atterberg Limits (Liquid Limits & Plastic Limits)
Laboratory test	・The four samples from the borehole No.2 should be conducted as the following tests. ➢ Unconfined test to the brick part designated on the picture above and the clay layer at foundation below if any, ➢ Specific Gravity, ➢ Natural Water Contents, ➢ Grain Size, ➢ Atterberg Limits (Liquid limits and Plastic limits)
Structural analysis	・Finite element analysis should be done considering the brick strength evaluated by the unconfined test ・The following cases on the structural analysis are assumed. ・All gates completely opened + Present traffic conditions

	① All gates completely opened +Planned traffic conditions (Traffic limitation) ② All gates completely opened +Planned traffic conditions (Traffic limitation)+ Effect of structural enhancement by the enhancing works (If the enhancing works is implemented.)

Recommendable works for the preservation

- ✓ In order to reduce the burden load on the existing DGRs except for Abo Gabal and Sahelyia regulators, the passable traffic shall be restricted. The allowable traffic could be the pedestrian, small vehicle and motorcycle. Especially as to the small vehicle and motorcycle, the allowable velocity should be regulated.
- ✓ In addition, all the gates shall be opened completely to alleviate the up-lift pressure to the basement of the regulators because the gate operation of the existing DGRs will not be required. Furthermore, dredging works should be done before the gates make full open (refer to chapter “18-4 Management of target canal bed elevation”).
- ✓ The significant damages investigated in 2010 such as eroded or fallen out bricks inside of the vents, and eroded apron at Bahr Yusef and Ibrahimia regulators should be rehabilitated. These works need the appropriate diversion works even in the winter closure season.
- ✓ The enhancement of the foundation and the regulator body should be implemented depending on the results of boring survey and/or the 3D finite element analysis.

20 Groundwater Simulation Analysis

20-1 Purpose of analysis and modeling approach

(1) Purpose of groundwater analysis

The NDGRs are set to be located 140 meters downstream of the existing regulators, while their ponding area will spread further down towards the residential area. The canal water level will increase by 2.7m[1] once NDGRs are operational. After construction, upstream of NDGRs, the water level will stay at 46.3m FWL, which is 0.3m higher than the current level.

Hydro-geologically, in some places, the canal water infiltrates the groundwater body, while in others, groundwater gushes out into the canals[2]. This phenomenon may be affected by the water head balance between canal water and groundwater. In general, changes in groundwater level take place seven days after changes in canal water level[3].

Improvement works have been implemented over the years as countermeasures against seepage from canals and related rises in groundwater level. These improvements are: (1) the extension of the Ibrahimia canal apron, (2) sheet piling, (3) protection of the canal bed in past constructions (DGRs in 1872, Abo Gabal intake in 1935), (4) and repair works (Ibrahimia canal in 1962). However, due to sewage effluence caused by recent urbanization, the groundwater level has been rising year after year. In fact, the foot of the canal banks and the basements of houses located near the DGRs, have shown signs of seepage.

In addition to this, the construction of NDGRs will result in a rise in canal water level, thereby increasing the groundwater level towards the center of Dirout city and its public facilities, such as mosques, stations, and highways, as well as its many private facilities such as shops, markets, and houses. The worst-case scenario includes serious direct damage to their structures, the floating of buildings, and the deterioration of structure foundations.

The aim of a groundwater simulation analysis is to predict and infer groundwater behavior after NDGRs construction, and to evaluate its environmental impact, and provide data that is useful in deciding on the necessity and scale of mitigation measures.

(2) Approaches for groundwater simulation analysis

In the case of groundwater simulation analysis with the purpose of developing an alternative design for groundwater insulation works and local seepage control, the model grid should be at least 1m. As regional hydro-geological information is scant, the model should cover as wide an area as possible to maintain model accuracy. Ideally, a broad model area with fine gridding (in 3D) is required to fulfill both purposes. However, in such a model, enormous amounts of input data and complicated calculation processes are required to run the data continuously being produced with every calibration-trial and case simulation. This may become an obstacle to the analysis, so to overcome it, two different models should be prepared to ensure work efficiency and model accuracy in the study. These are shown as follows.

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[1] Annual lowest level of canal water observed was EL 43.7 in Ibrahimia canal from September 2015 to October 2016 not counting the winter-closure period (January to February 2015). When compared to the 46.3m of FWL after NDGRs construction, the difference is 2.7m.

[2] From the water level records measured at canal gauges and groundwater monitoring wells, it is considered that canal water flows (recharges) to groundwater body in the summer (high water season), while in the winter (low water level season), groundwater flows back (discharges) to canals.

[3] Aquifers in the Dirout area are regarded as "confined or semi-confined (multilayered) aquifer[s]" composed of a coning silty-clay surficial layer and permeable layers of sandy and gravely sediment. The changes in canal water level are therefore translated into pressure on groundwater.

Regional model (larger model): covers the center of Dirout city surrounded by DGRs and NDGRs capable of dealing with regional groundwater flow.

Detailed model (sub-region/portion model): covers site of NDGRs and applies specific seepage analyses to design groundwater control works of NDGRs.

In the first stage of the analysis, the regional model is constructed with the necessary calibrations using monitoring records to evaluate groundwater flow near the NDGRs and the surrounding area. The detailed model is then upgraded from the regional model, and refined to use grids small enough to evaluate an alternative groundwater control plan. To this end, MODFLOW USG (ver3, 2015)[4] is applied with a refined Quadtree grid[5]. The work steps of modeling are shown in Figure 20-1.1.

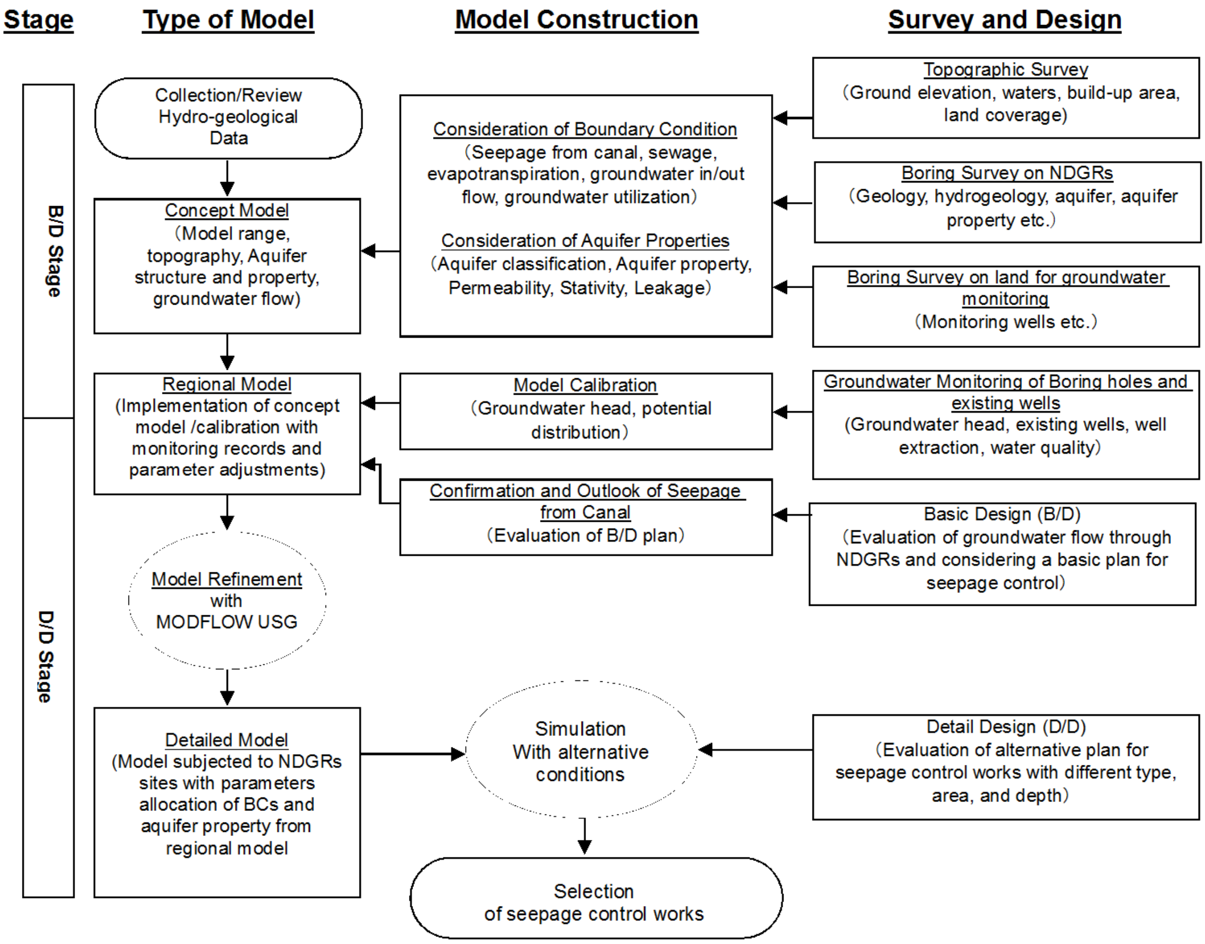
Stage
Type of Model
Model Construction
Survey and Design
B/D Stage
D/D Stage
Collection/Review Hydro-geological Data
Concept Model (Model range, topography, Aquifer structure and property, groundwater flow)
Regional Model (Implementation of concept model /calibration with monitoring records and parameter adjustments)
Model Refinement with MODFLOW USG
Detailed Model (Model subjected to NDGRs sites with parameters allocation of BCs and aquifer property from regional model
Consideration of Boundary Condition (Seepage from canal, sewage, evapotranspiration, groundwater in/out flow, groundwater utilization)
Consideration of Aquifer Properties (Aquifer classification, Aquifer property, Permeability, Stativity, Leakage)
Model Calibration (Groundwater head, potential distribution)
Confirmation and Outlook of Seepage from Canal (Evaluation of B/D plan)
Simulation With alternative conditions
Selection of seepage control works
Topographic Survey (Ground elevation, waters, build-up area, land coverage)
Boring Survey on NDGRs (Geology, hydrogeology, aquifer, aquifer property etc.)
Boring Survey on land for groundwater monitoring (Monitoring wells etc.)
Groundwater Monitoring of Boring holes and existing wells (Groundwater head, existing wells, well extraction, water quality)
Basic Design (B/D) (Evaluation of groundwater flow through NDGRs and considering a basic plan for seepage control)
Detail Design (D/D) (Evaluation of alternative plan for seepage control works with different type, area, and depth)

Figure 20-1.1 Approach for groundwater simulation analysis

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[4] MODFLOW-USG: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation (http://water.usgs.gov/ogw/mfusg/)

[5] "Quadtree" is a refining method which modifies the normal grid (uniformed spacing structured grid) into a fine and unstructured grid, capable of detailed control of in/output of model.

20-2 Preparation of regional model

The regional model was constructed with due consideration of (1) groundwater recharge from the surface and groundwater flow in/out, and (2) the capacity of the groundwater reservoir underneath the study area.

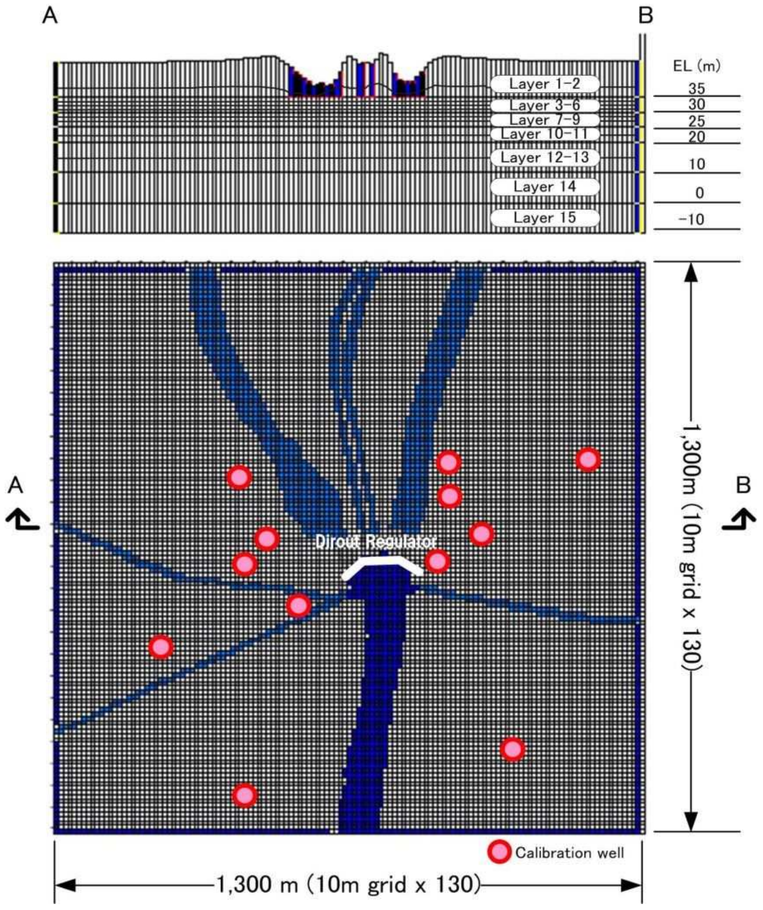

Figure 20-2.1 Model grid (regional model)

In the following subsections, the main components of the model construction are described: (1) analysis area (model range), (2) design of FDM grid, (3) boundary conditions (BCs), and (4) hydro-geological properties.

(1) Analysis area (model range)

The piling-up of thick clay material is observed at 20m depth downstream of the Abo Gabal regulator, extending to the Irad Delgaw canal and further down to the left bank of the Bahr Yusef canal. With the exception of piling-up clay, Neo-Nile deposits are layered with horizontal homogeneity extending over the Dirout area. Restricted by this layered structure, groundwater flows outwards from the channels.

Relying on an empirical formula, groundwater inflow from the canals is supposed to be 300m to 350m (Kusakin, 1953).

Due to the lack of available hydrological data in the peripheral vicinity of the model, and to maintain model reliability, influenced area should be covered by a sufficient margin. Adding a 200m buffer zone to the 300m inference area, the recharge zone in the analysis is a total of 500m away from the canal. Furthermore, at a canal width of 300m and a total area of 1,300m × 1,300m is properly required for the groundwater modeling analysis.

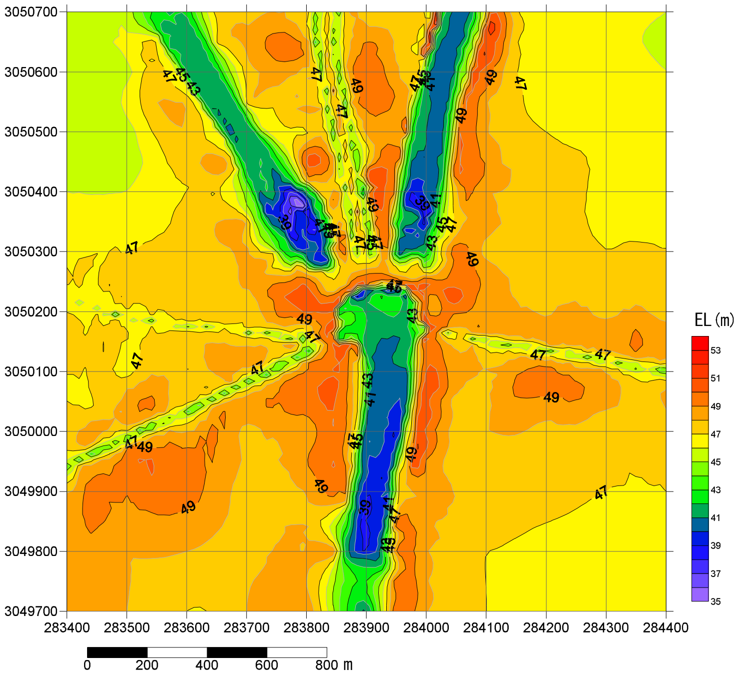

Figure 20-2.2 Ground elevation of model area

As for the depth covered by the analysis, at least 50m of clearance is required for comparing the design of the cut-off plate and bearing pile (see Figure 20-2.1).

(2) Design of FDM grid

In accordance with the purpose of the regional model, grid size is refined to 10m in plane (x, y) for whole model range (1,300m×1,300m). While at depth (z), 15 layers are applied from the ground level to EL -10m. There are 253,500 grids in total (130 in E-W direction × 130 in N-S direction × 15 layers in depth).

(3) Boundary conditions (BCs)

The center of Dirout is located on the embankment area, and is 3 or 4m higher than the surrounding farmland. The farmland extends along model borders and shows EL.46m to EL.47m, while the area adjoining the DGRs is EL.50m high (see Figure 20-2.2). The groundwater level (or head) is observed to be in the range of 1.5 to 8.5m below the ground surface.

Since the Dirout area suffers arid climate characterized by very little rainfall throughout the year, the canals leakage to the aquifer is the main source of groundwater. Thus, the gradients of groundwater heads decline from the city center (of regarded area from canals) towards the model borders.

Regarding the groundwater usage in the study area, the groundwater is utilized as the supplemental water resources for daily human activity. In fact, according to the inventory survey it was found that eight wells exist along the Abo Gabal canal in the study area.

Taking hydro-geological condition of this range into account, three boundary conditions are assigned to the regional model as shown in Table 20-2.1 and Figure 20-2.3.

Table 20-2.1 Boundary conditions (BCs) of groundwater model

Type of BCs	Description	MODFLOW Package
Head-dependent flux boundaries between canal bottom and aquifer	In the canal, flow of water into or out of aquifer is dependent on difference between canal water level and groundwater head. If canal water level is higher than groundwater head, then the canal moves water to the aquifer.	River package (RIV)
Specified flux boundary to individual pumping wells	At pumping wells, a specified amount is extracted from the aquifers. In the model, observed values from five wells are given and extracted from sandy layers.	Well package (WEL)
Specified head boundary between model area and its outside.	Along model margin, flow of water from/out of model area is dependent on the difference between specified head and groundwater head in the model.	Time-Variant Specified-Head package (CHD)

When calculating the amount of seepage from canals (groundwater recharge and outflow), the canals are first divided into eight sections: upstream and downstream of Ibrahimia canal, Bahr Yusef, Abo Gabal, Irad Delgaw, Sahelyia, Diroutiah, and Badraman canals. Then, head-dependent flux boundaries that consider canal conditions are drawn, and seepage is then calculated from: (1)

the given values of canal water level, (2) permeability and thickness of channel-bed sediments, and (3) the width and length of channels.

As for groundwater extraction, a specified flux boundary is adopted with the daily rate and screen position taken from the well inventory survey conducted in April 2016.

The exchange amount of water flowing in/out of model range is calculated with specified head boundary taken from the groundwater potential distribution based on the groundwater monitoring carried out at each step of the calculation.

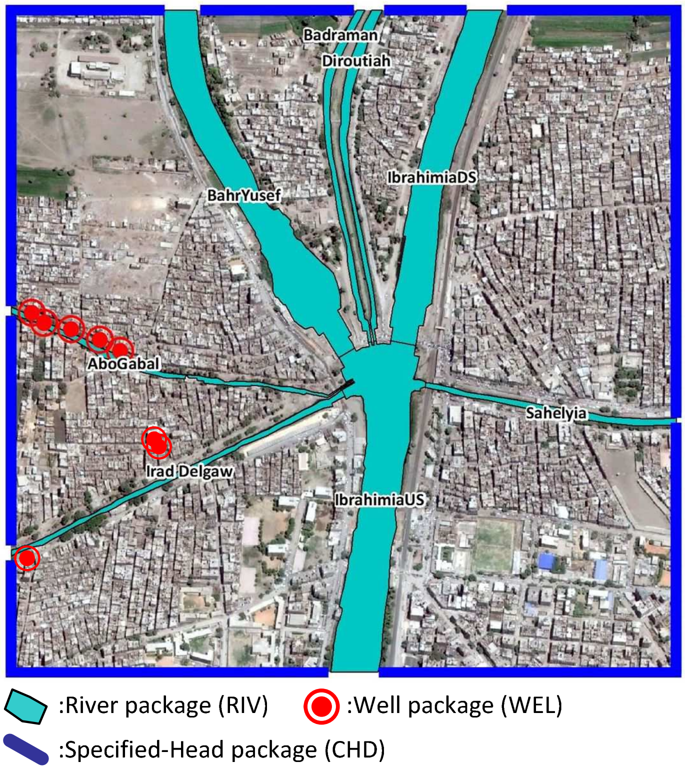

Figure 20-2.3 Boundary condition (MODFLOW PACKAGE)

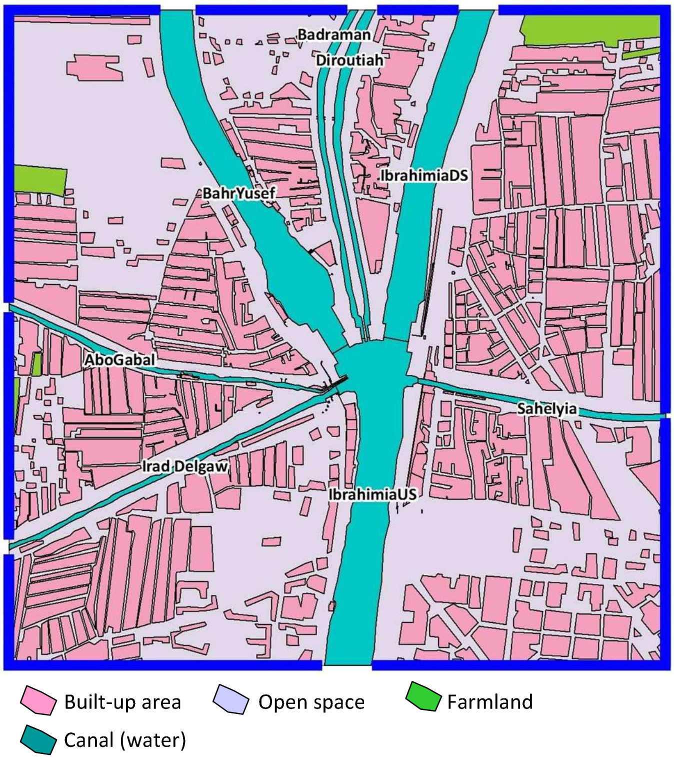

Figure 20-2.4 Land cover classification

(4) Model property

Input data for model property is obtained through an analysis of hydrostratigraphy of the model area, involving both the surficial layer (recharging zone: unsaturated zone) and the aquifer (saturated zone). The characteristics of the unsaturated and saturated zones are described in the following subsections.

1) Hydrostratigraphy

Non-marine alluvial and Pleistocene deposits are within the model range. In the boring survey (30m in depth), the grading structure is observed through beds and geologic members. The upper layer (about 10m thick) is composed of silty clay, but further down, it gradually changes into sandy facies with gravel, and further still it turns into coarse sand with granular gravel or pebble, and finally into boring holes (EL.19m to EL.25m) at the very bottom.

This strata correlates to flood deposits during the past climate change after Middle Pleistocene (40,000 years ago) and broadly covers the Nile Valley lowlands. It is generally referred to as ‘Neo-Nile deposit’ and is more thickly distributed along the Nile main channel and thins out the further it gets away from it. From the boring survey, the layers have been found to thicken on the right bank of the Ibrahimia canal, the side closer side to Nile main channel, and slightly thin out on the left bank of the Bahr Yusef canal. The strata are also grouped into four layers; Nc, Nm, Ns, and Ng, which are horizontally consistent with the model range.

Hydro-geological properties are classified into: (1) groundwater recharge at ground surface, (2) aquifer properties controlling groundwater flow, and (3) artificial underground structure.

a) Properties of unsaturated zone (Groundwater recharge and evapotranspiration)

In the model range, the surficial to unsaturated zone is about 10m thick, and consists of impervious silty-clay. Due to scant rainfall, natural recharge has hardly taken place in the model range. Thus, groundwater recharge occurs exclusively by canal water leakage, sewage, the water supply network, and surplus water from the irrigation field.

In Dirout city, the water supply system is constructed by the main stream of the Nile river and a 50 litre/day/cap[6] of water is provided for 25,000 people within the model area (1,300m×1,300m=169ha)[7]. Actually, 1,250 m^3/day of water is utilized in the model range, and 90% of it was discharged as sweage in the area.

However, some sewage is collected by tank truck, due to the insufficient capacity of sewage treatment in Dirout city. Most sewage waste is disposed of in the surficial to unsaturated zone through sewage inlets and the infiltration holes of individual residences and multi-apartment buildings.

In the open spaces, playground, park, etc., the direct evaporation from shallow aquifer is supposed to take place in the dry sunny season. In addition, some groundwater is lost through transpiration and as a result of the trees planted along the roadsides and in the park.

In the farmland located outside the built-up area, irrigation water is supplied all year long, hence some water is consumed by the crops and what remains is recharged to shallow aquifer.

According to land cover classification, the recharge/evaporation zone properties are classified into three types, and their respective potentials are shown in Figure 20-2.4.

b) Property of saturated zone (aquifer property)

In the model range, there is aquifer in the deposits of thick Neo-Nile alluvium. The layer facies are characterized by cohesive silt (Nc) on the upper horizon, changing to coarser sediments of silt

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[6] According to International Development Research Center (2007), design water supply amount is 52 lit/day/cap. If a leakage rate of 32% is applied, the amount of water supply is estimated to be 78 lit/day/cap.

[7] Population living in model range is estimated based on the Dirout city population of 72,856（492ha）sourced from National Information Center (2006).

(Nm), sand (Ns), and granular gravel (Ng) respectively toward the lower horizon. Hydraulically, aquifers are classified by permeability and storativity. The layers are horizontally homogeneous, each layer's properties remaining consistent.

In the area from the Abo Gabal regulator to the Bahr Yusef canal, thick fill materials (F) pile up on the clay (Nc) and silt (Nm) layer. These act as an aquiclude covering a sandy layer on the lower horizon of the Neo-nile deposit. This hydro-geological structure confines the groundwater in the model range. Regarding the aquifer condition, upper layers (F and Nc) act as 'confining layers', while the lower layers (Nm, Ns, and Ng) are the 'confined layers' of the model.

The permeability of each layer is accounted for based on observation records. In the field survey, 30 permeability tests of the NDGRs' foundation have been conducted so far. Of all the values, the range of $k=1.8\times10^{-5}$ to 1.6×10^{-3}cm/sec and the median value of 1.9×10^{-4} cm/sec[8] are shown in Figure 20-2.5.

As for the respective layers, fill deposit (F) is $k=2.2\times10^{-4}$ cm/sec in median value, $k=5.6\times10^{-5}$ cm/sec of Nc, $k=4.2\times10^{-4}$ cm/sec of Nm, $k=4.2\times10^{-4}$ cm/sec of Ns, and $k=2.7\times10^{-5}$ cm/sec of Ng layer are as shown in Figure 20-2.6.

The permeability coefficient of each layer and the value corresponding to the depth-zone are used to provide an initial value of the regional model[9] (see Table 20-2.2).

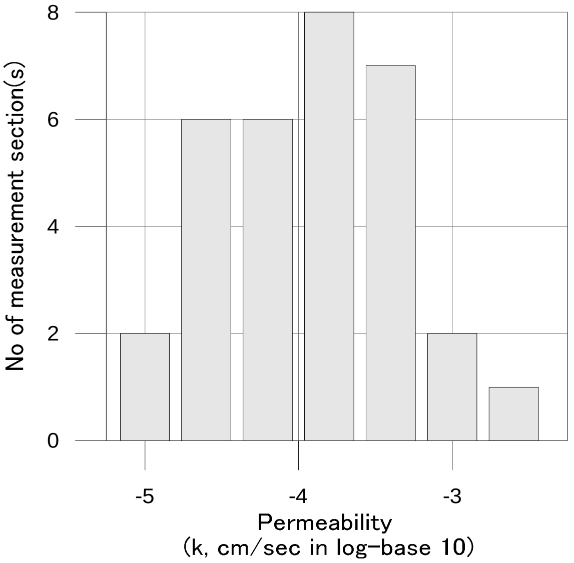

Figure 20-2.5 Distribution of observed permeability

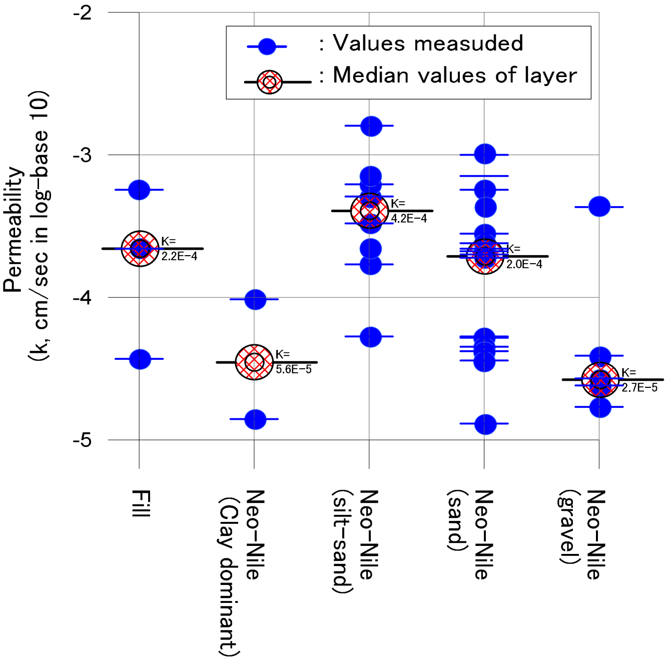

Figure 20-2.6 Permeability of each layer

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[8] Median value of permeability coefficient (1.9×10-4 cm/sec) is regarded as a common value of 'unconsolidated sand with silt and finer layer' (e.g. k=10-5~1.6×10-2 is given by Freeza R.A. and Cherry (1979).

[9] Specific yield and storage have not been observed by field survey, so a value corresponding to layer faces is allocated to respective depths (model layer) and specified area (coverage of impervious fill).

Table 20-2.2 Average permeability by depth

Layer No.	Symbol	Type of Aquifer	EL(m)	Permeability*1			Storage Coef.*2	
				Horizontal (x,y)		Vertical (z)	Spec. Yield	Spec. Storage
				$k_{x,y}$ (cm/sec)	$k_{x,y}$ (m/day)	k_z (m/day)		
Fill (Silt/Clay/sand)	F	Unconfined （confining）	0~30m	2.7.E-05	0.03	0.03	0.03	-
1 (Silt～Clay)	Nc		0~35m	4.2.E-04	0.37	0.07	0.05	-
2 (Sand, loose, fine)	Nm	Confined	35m~30m	1.2.E-03	1.06	0.21	0.1	0.001
3 (Sand, medium)	Ns		30m~25m	3.2.E-04	0.28	0.06		
4 (Sand, medium)	Ns		25m~20m	2.7.E-04	0.24	0.05		
5 (Sand, dense, coarse)	Ng		20m~10m	4.5.E-04	0.39	0.08		
6 (Sand, dense, coarse)	Ng		10m~0m					
7 (Sand, dense, coarse)	Ng		0m~-10m					

* 1: Permeability test did not consider horizontal and vertical direction, observed value is thus regarded as horizontal permeability, and 1/5 of horizontal permeability is set as vertical permeability for the model's initial value.

* 2: Storage coefficient was not obtained by field test, and the value corresponding to facies is thus initially applied in the model.

c) Underground structure

In the construction of DGRs, some countermeasures against canal seepage must be taken at the very foundation. In 1962, improvement works were undertaken due to the rise in the water level upstream of the DGRs. These improvements included the extension of the Ibrahimia canal apron, wooden driven sheet piles, and canal bed protection works. However, no detailed records of the locations or extent of those works exists today. Thus, based on the monitored water heads and their distributions, the model assumed the construction range of the cut-off plate (the impervious wall lining) was installed on the Sahelyia, Ibrahimia, Abo Gabal, and Irad Delgaw regulators, until the depth of EL.35m.

(5) Assigned conditions to the model

The boundary conditions are arranged and classified for the concept model and then transferred into a GIS data set and assigned to the model under a specified format of [10]MODFLOW 2000 package. The applied packages are shown in Table 20-2.3.

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[10] MODFLOW is the modular finite difference flow model developed by USGS. One of the features of MODFLOW is its available source code (free code). Given its transparency, and the data density of this project, the use of MODFLOW is superior in terms of accuracy and efficiency for the study to FEM.

Table 20-2.3 Boundary condition and MODFLOW package

Boundary Condition (BCs)	Location	Type	MODFLOW package
Boundary between model area and outside (groundwater in/out flow)	Model margin	Constant head boundary	Time-Variant Specified-Head package (CHD)
Boundary between canal bottom and aquifer (seepage/groundwater inflow)	Waters of canals	Head-dependent flux boundaries	River package (RIV)
Wells (groundwater extraction from aquifer)	Well points	Constant flux boundaries	Well package (WEL)
Property (Pros)	**Location**	**Type**	**MODFLOW package**
Recharge (discharge sewage to aquifer)	City/built-up area	Constant flux boundaries	The recharge package (RCH)
Evapotranspiration (direct evaporation to groundwater)	open spaces etc.	- do -	Evapotranspiration package (EVT)
Evapotranspiration (Evapotranspiration from irrigation area)	Irrigation farmland	- do -	Evapotranspiration package (EVT)

(6) Calibrating data

The model calibration was made with monitoring records (groundwater head) of 13 wells (see Figure 20-2.7). Monitoring began in September 2015, and minimum value was observed to be EL.41.55m while maximum value was EL.44.22m. The difference between them is over 2.7m (see Figure 20-2.8). The shallowest depth was observed in the summer (high water period) to be 1.75m at BH-N13.

The groundwater infiltration along canals increases during the high water period from June to August. For the purpose of groundwater modeling, and evaluating groundwater interference caused by NDGRs, the highest water level shall be applied for model calibration in the interest of safety.

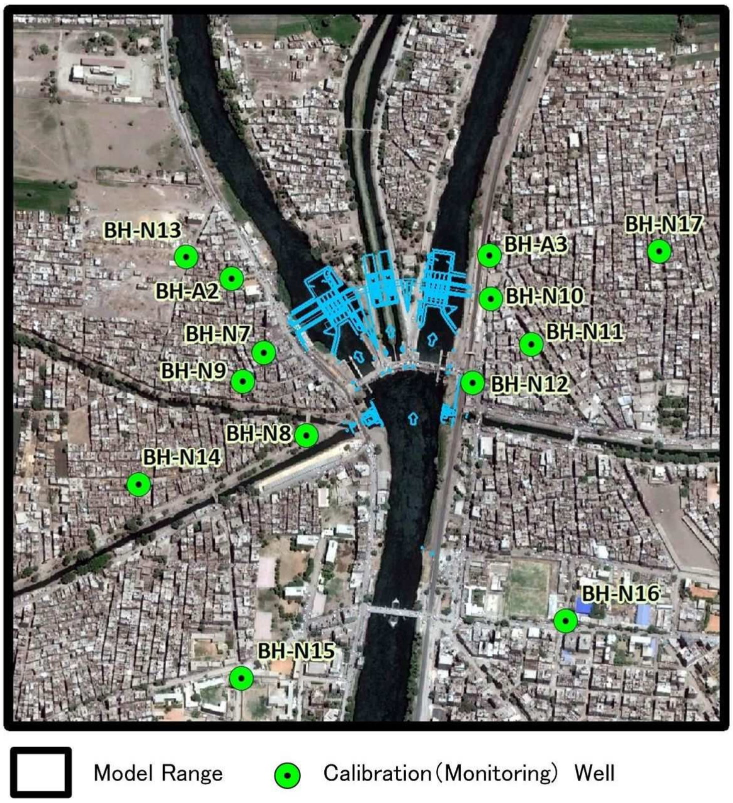


Figure 20-2.7 Calibration Point (Monitoring well)

In the period from September 2015 to February 2017, the target period disregarded was that from 20 June 2015 to 27 July 2016 (see Table 20-2.4 and Figure 20-2.8). For calibration records, the data for 13 selected monitoring wells on 27 July 2016 was collected and appropriately allocated to model layers with due reference to screen depth (see Table 20-2.5).

Table 20-2.4 Maximum/Minimum groundwater head and depth (Sep 2015 to Feb 2017)

Piezometers	Max. Depth (m)	Min. WL (EL.m)	date	Min. Depth (m)	Max. WL (EL.m)	date
BH-N7	5.38	41.93	18/1/2017	3.17	44.14	27/7/2016
BH-N8	5.62	41.93	18/1/2017	3.46	44.09	17/8/2016
BH-N9	5.06	41.88	18/1/2017	2.83	44.11	27/7/2016
BH-N10	6.88	41.88	18/1/2017	4.56	44.20	27/7/2016
BH-N11	5.64	41.89	18/1/2017	3.34	44.19	27/7/2016
BH-N12	8.82	41.90	18/1/2017	6.54	44.18	27/7/2016
BH-N13	3.93	42.02	18/1/2017	1.75	44.20	27/7/2016
BH-N14	4.81	42.03	18/1/2017	2.77	44.07	17/8/2016
BH-N15	4.96	41.84	18/1/2017	2.90	43.90	10/8/2016
BH-N16	4.78	41.55	18/1/2017	2.60	43.71	10/8/2016
BH-N17	4.83	41.66	18/1/2017	2.47	44.02	27/7/2016
BH-A2	5.00	42.00	18/1/2017	2.83	44.17	27/7/2016
BH-A3	7.56	41.83	18/1/2017	5.17	44.22	27/7/2016

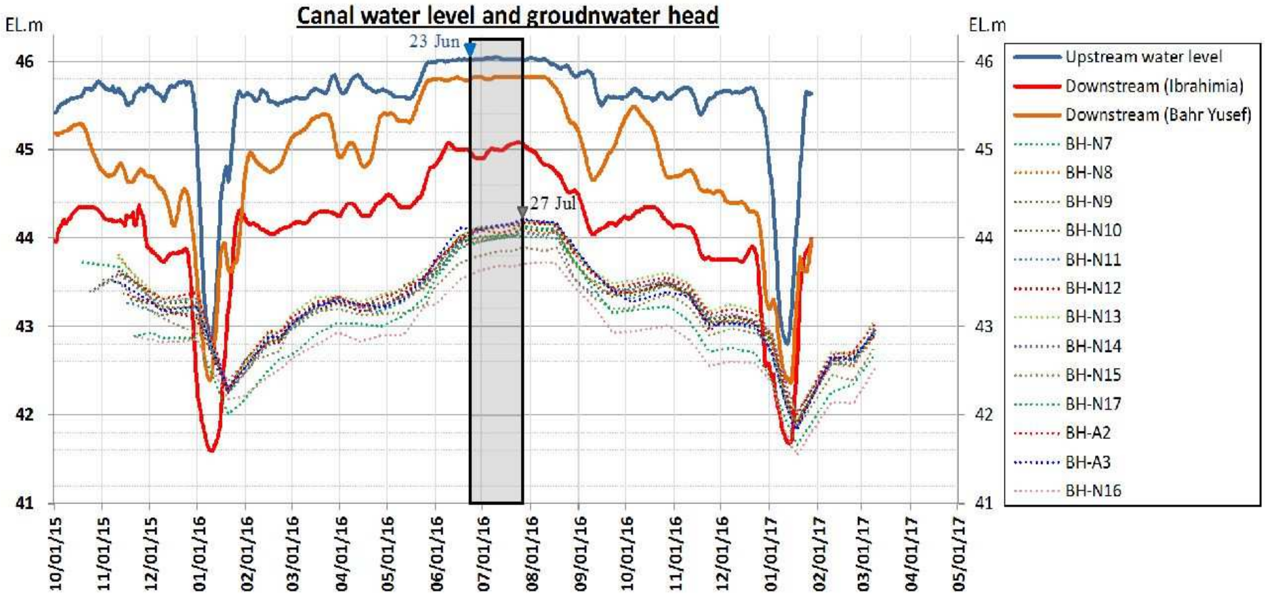


Figure 20-2.8 Change in groundwater head and canal water level (Sep 2015 to Feb 2017)

Table 20-2.5 Calibration data (record of 13 monitoring wells on 27 July 2016)

No		Location			Groundwater Head	
	Monitoring Hole	X (UTM36, m)	Y (UTM36, m)	Z (EL.m)	Measurement Value (EL.m)	Model Layer
1	BH-N7	283664	3050278	47.308	44.14	2
2	BH-N8	283741	3050126	47.509	44.08	2
3	BH-N9	283626	3050225	47.110	44.11	2
4	BH-N10	284076	3050375	48.835	44.20	1
5	BH-N11	284150	3050292	47.615	44.19	2
6	BH-N12	284043	3050222	50.913	44.18	1
7	BH-A2	283606	3050413	46.997	43.17	2
8	BH-A3	284074	3050454	49.593	44.22	1
9	BH-N13	283523	3050452	45.885	44.20	3
10	BH-N14	283437	3050038	46.841	44.06	3
11	BH-N15	283623	3049686	46.769	43.90	3
12	BH-N16	284212	3049791	46.530	43.71	3
13	BH-N17	284383	3050462	46.670	44.02	3

(7) Model calibration

For the automatic calibration, the observed permeability of the Nc to Nm layer was used as an initial value[11]. At thresholds, initial values were adjusted to minimize residual error between the observed and calculated values. Calibration results are shown in Table 20-2.6.

Table 20-2.6 Calibration summary for aquifer coefficients

Calibration Points			Groundwater Head（ELm)		
No.	Monitoring Hole	Model Layer	①Observed	②Calculation	③Residual
			27/July/2016	By Case 10	Dif=①-②
1	BH-N7	2	44.14	44.18	-0.04
2	BH-N8	2	44.08	44.09	-0.01
3	BH-N9	2	44.11	44.07	0.04
4	BH-N10	1	44.2	44.10	0.10
5	BH-N11	2	44.19	44.20	-0.01
6	BH-N12	1	44.18	44.11	0.07
7	BH-A2	2	44.17	44.27	-0.10
8	BH-A3	1	44.22	44.15	0.07
9	BH-N13	3	44.2	44.09	0.11
10	BH-N14	3	44.06	44.02	0.04
11	BH-N15	3	43.9	43.94	-0.04
12	BH-N16	3	43.71	43.79	-0.08
13	BH-N17	3	44.02	43.96	0.06
				Average	0.02

---

[11] Model calibration was made mainly using Parameter Estimation and Uncertainty Analysis: PEST (http://wi.water.usgs.gov/models/pestplusplus/) and with 0.2~5.0 x observation value of thresholds.

Table 20-2.7 Comparison between observation records and calculation values

Layer No.	Symbol	Type of Aquifer	Depth		Permeability (Initial /before calibration.)		Permeability (calibrated)			Storativity (calibrated)	
			EL(m)		Horizontal（Kx,y)		Horizontal（Kx,y)		Vertical（Kz)	Specific Yield	Specific Storage
			top	bottom	cm/sec	m/day	cm/sec	m/day	m/day		
1-5	F	Un-Con.	GL	30.0	2.7.E-05	0.03	2.9.E-05	0.03	0.025	0.03	-
1	Nc	confining	GL	36.0	4.2.E-04	0.37	5.6.E-05	0.05	0.035	0.05	-
2	Nc/m	Confined	36.0	35.0	1.2.E-03	1.06	1.2.E-03	1.06	0.182	0.1	0.001
3	Nm		35.0	33.8			1.2.E-03	1.06	0.182		
4	Nm		33.8	32.5			1.2.E-03	1.06	0.182		
5	Nm		32.5	31.3			1.2.E-03	1.06	0.182		
6	Nm		31.3	30.0			1.7.E-04	0.15	0.065		
7	Ns		30.0	28.8	3.2.E-04	0.28	1.7.E-04	0.15	0.065		
8	Ns		28.8	27.5			1.7.E-04	0.15	0.065		
9	Ns		27.5	25.0			4.6.E-04	0.40	0.08		
10	Ns		25.0	22.5	2.7.E-04	0.24	4.6.E-04	0.40	0.08		
11	Ns		22.5	20.0			9.3.E-04	0.80	0.16		
12	Ng		20.0	15.0	4.5.E-04	0.39	9.3.E-04	0.80	0.16		
13	Ng		15.0	10.0			9.3.E-04	0.80	0.16		
14	Ng		100	0.0			9.3.E-04	0.80	0.16		
15	Ng		0.0	-10			9.3.E-04	0.80	0.16		

The calibrated aquifer coefficient is only slightly different from the initial value, in particular, the aquifer coefficient of the Nm layer of loose fine sand located just below the regulator. Seepage flow is not changed and remains at observation values.

The calculation results are acceptably different from observation values, less than 2cm on average at 13 calibration points, with variations of 1cm to 11cm. The model can reproduce groundwater flow and head in the vicinity of NDGRs. The model parameters are fixed and the current conditions of groundwater head and flow flux are recalculated in case of 27 July 2016 (see Figure 20-2.9 of case 10 of current model[12]).

The results shown are those of the monitoring survey. That is, groundwater flows down to model borders in response to rise in canal water level, and disturbances are found as a result of the minor variation of local rises and depressions influenced by partial recharge and evapotranspiration caused by sewage disposal, pumpage and so on.

---

[12] Due to the unavailability of annual highest level of groundwater in the B/D stage, the previous model (case 0) was constructed with the data from 09 Dec 2015, before the 2015 winter closure. In the D/D stage, annual highest data from 27 July 2016 was applied to the current model as case 10.

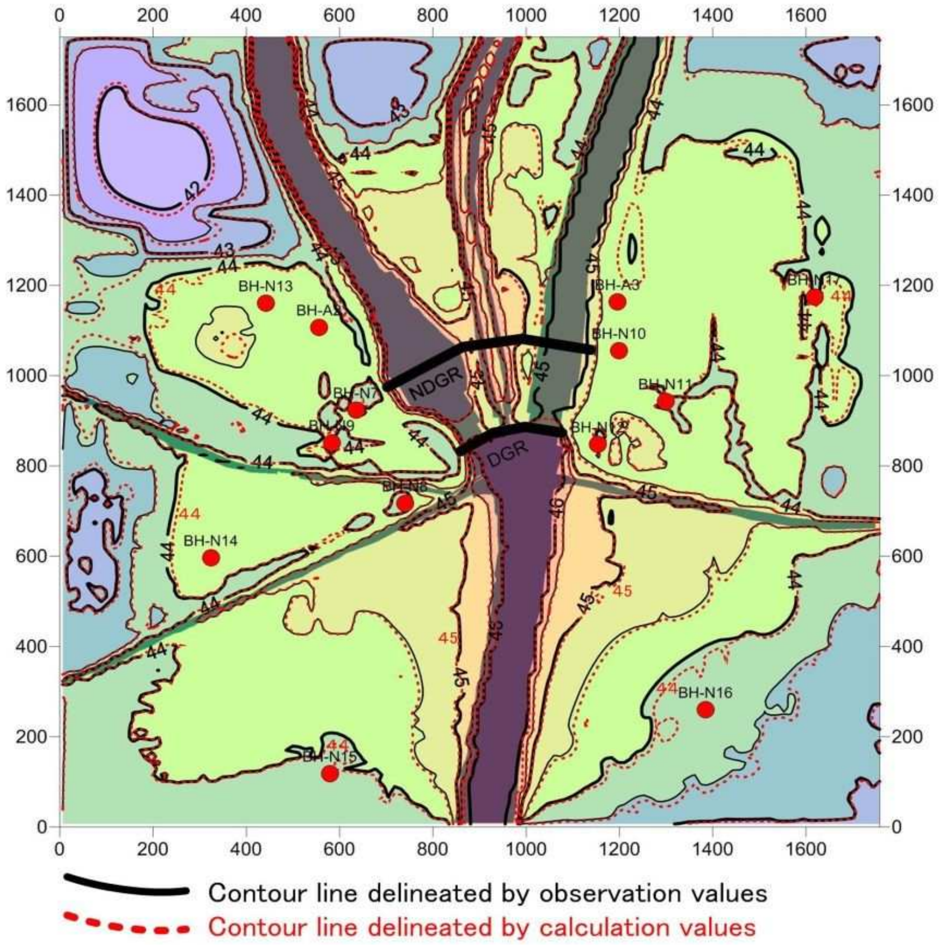


Figure 20-2.9 Comparison between observation and calculation values

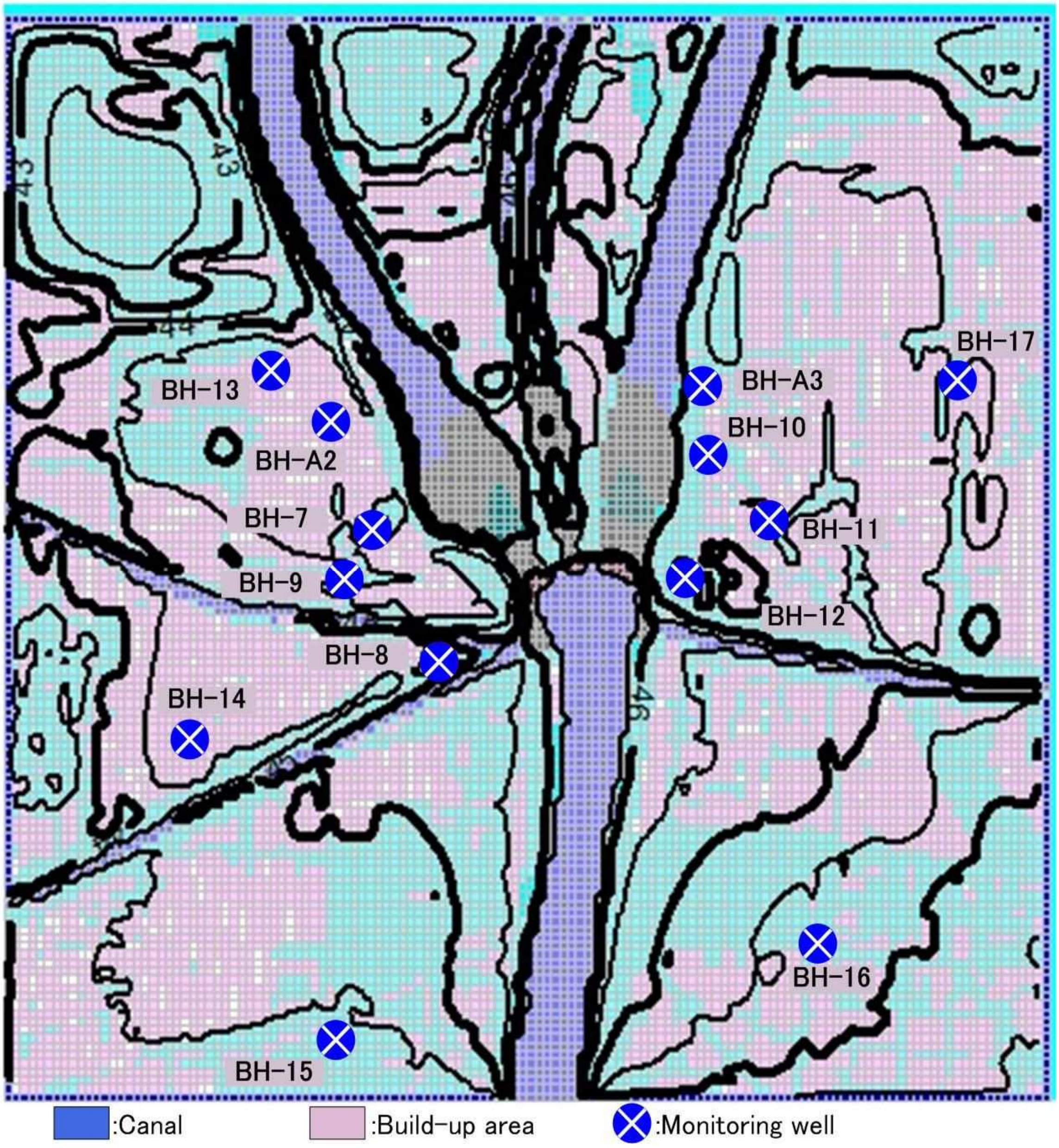


Figure 20-2.10 Contour map of groundwater head
(case 10, current model on 27 July 2016）

20-3 Preparation of detail model

For the purpose of groundwater modeling, which predicts groundwater interference after NDGRs construction, a regional model needed to be re-constructed to achieve a more precise simulation. The alternative study for groundwater control works covers the embankment, steel sheet piles, and so on. The detailed model has a small grid size capable of presenting the different dimensions of alignment and depth. The detailed model is therefore rebuilt from a refined regional model on an unstructured grid. In the following subsection, the process of making the detailed model is described.

(1) Grid refining

The construction area of NDGRs is subjected to grid refining. Using the Quadtree method on a 10m regional grid, a subdivision of 1/2 (5m), 1/4 (2.5m), and up to 1/8 (1.25m) are added on in order. In the last division, the total grid number reaches 531,735 (35,449 grids x 15 layers). The gridding structure of the detailed model is shown in Figure 20-3.1.

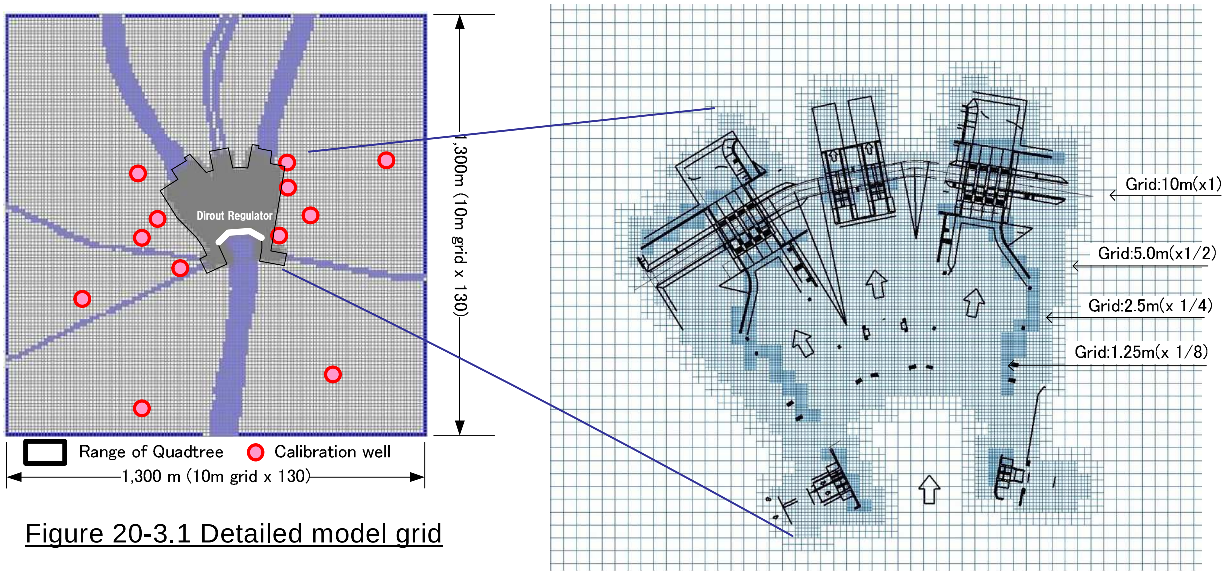


Figure 20-3.1 Detailed model grid

(2) Confirmation of model reliability (case 10 current condition)

The current groundwater status on 27 July 2016 of annual maximum water level is reproduced by the detailed model. In Figure 20-3.2, the distribution of groundwater head and flux are shown. Groundwater flowing east and west originated from DGRs (as a recharge source) with minor disturbances reflected on the pathways to model edges. An exchange of water at surface/groundwater systems, such as inflow of sewage, and loss by evaporation, are assumed through the distribution of groundwater head and flux.

The hydraulic gradient is 1/750 at the east (Ibrahimia) side and 1/600 at the west (Bahr Yusef) side. Due to the impervious silty clay overlain on the Irad Delgaw canals to the left bank of Bahr Yusef canal, the Bahr Yusef side shows a steeper hydraulic gradient than the Ibrahimia side. The water mass-balance in model range indicates 984m^3/day of infiltration from canals as shown in Table 20-3.1.

Table 20-3.1 Summary of mass water balance in the model area (case 10, current condition)

Boundary Condition	Inflow		Outflow		Balance		Remarks
	m^3/day	mm/day	m^3/day	mm/day	m^3/day	mm/day	
Canal	985	0.58	1	0	984	0.58	In/outflow, canals
Model boundary	147	0.09	403	0.24	-256	-0.15	In/outflow, model range
Recharge /evapotranspiration	435	0.26	1118	0.66	-683	-0.4	Inflow of sewage/ evapotranspiration
Well extraction	-		45	0.03	45	0.03	Pump up from well
Total	1567	0.93	1567	0.93	0	0)	-

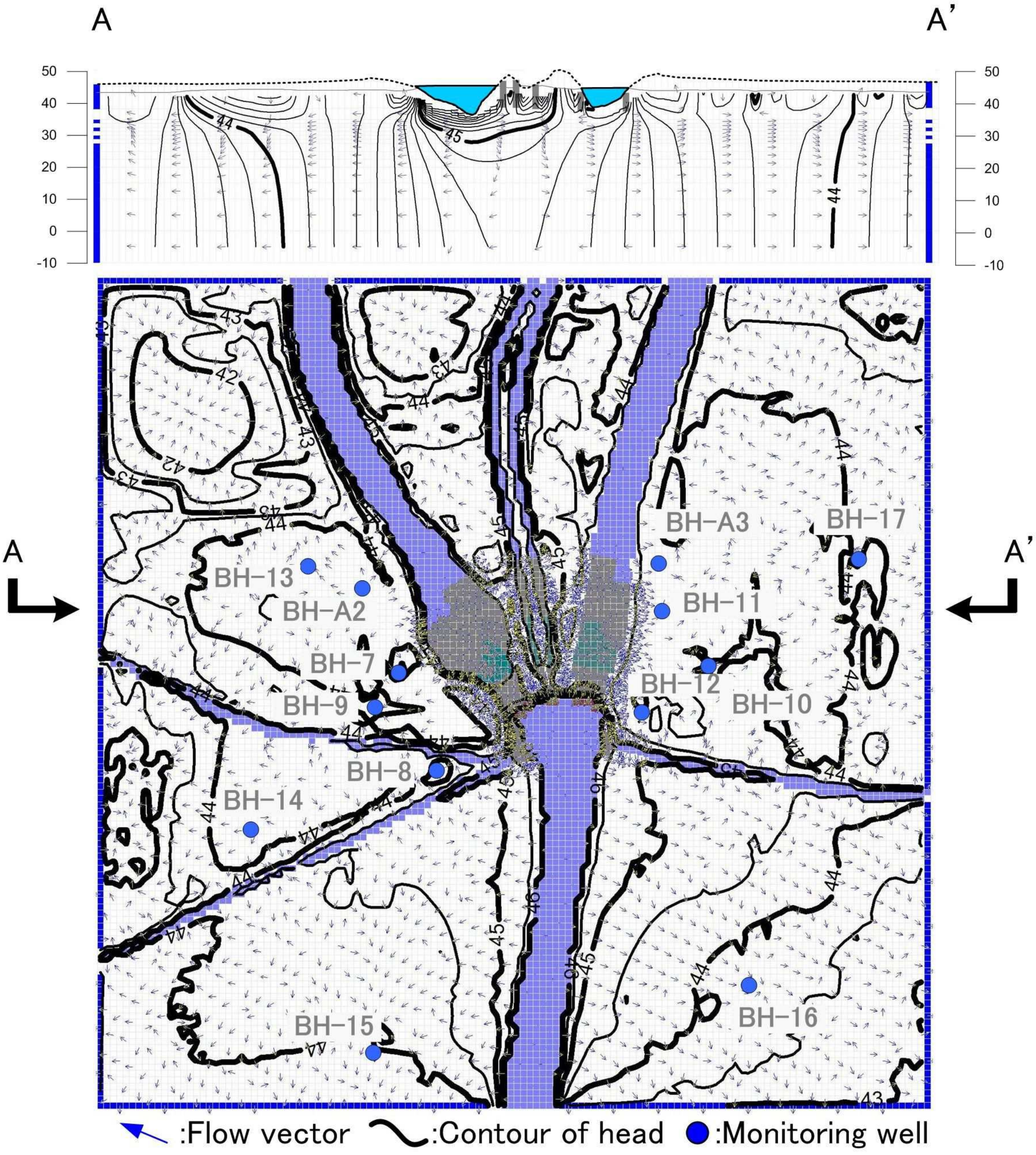


Figure 20-3.2 Groundwater head and flow vector (case 10)

20-4 Simulation study (Case 11, 12, and 13)

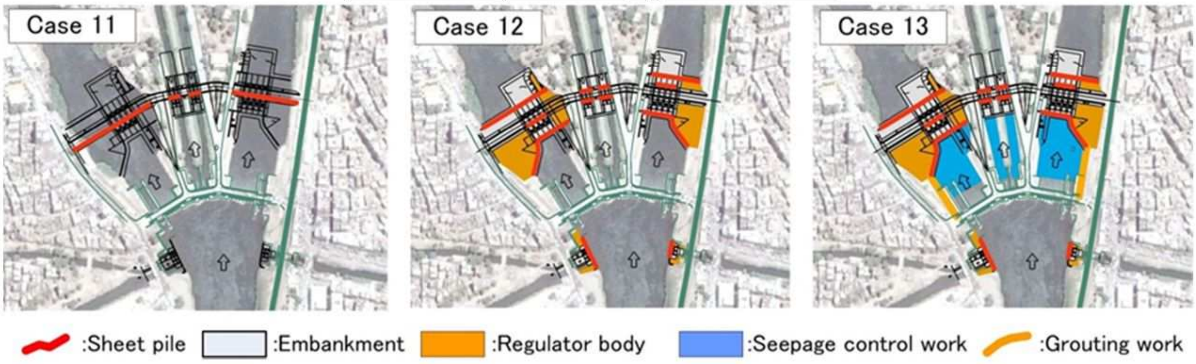
In the detailed analysis, case simulations are subjected to additional evaluation of seepage control in conjunction with embankments and steel sheet piles and so on. Simulations determine the acceptable measurements of components, areas, alignments, and amounts. Potential alternatives and their components and various configurations, may contribute to groundwater fluxes; causing seepage in unexpected directions and reducing groundwater inference. Groundwater simulations of selected alternatives are carried out as shown in the following subsections.

(1) Case condition

The full water level of Ibrahimia canal is planned as EL.46.3m (FWL) to simulate substantial influence by the NDGRs construction. Embankments and sheet pilings in revetment, bed protection works, and others are also included in simulations, with four cases shown in Table 20-4.1.

Table 20-4.1 Conditions of simulation cases

<table>
<tr><th rowspan="2">Case</th><th colspan="5">Condition</th><th rowspan="2">Remarks</th></tr>
<tr><th>Canal water level</th><th>Sheet Pile</th><th>Embankment</th><th>Seepage control work</th><th>Grouting</th></tr>
<tr><td>Case 10</td><td>Current</td><td>×</td><td>×</td><td>×</td><td>×</td><td>Current status model (June-July/2016)</td></tr>
<tr><td>Case 11</td><td>Plan</td><td>○</td><td>×</td><td>×</td><td>×</td><td>Sheet pile/cut-off wall along axis</td></tr>
<tr><td>Case 12</td><td>-do-</td><td>○</td><td>○</td><td>×</td><td>×</td><td>D/D plan (sheet pile, Regulator, embankment)</td></tr>
<tr><td>Case 13</td><td>-do-</td><td>○</td><td>○</td><td>○</td><td>○</td><td>D/D plan + seepage control for channel bed, grouting</td></tr>
<tr><td colspan="7">
Alternative layout of seepage control works



Note: Permeability is given as
Sheet pile: $k=2.3\times10^{-5}$ cm/sec x 1.25m thickness of wall (1 grid)
Canal water inflow via embankment/regulator/foundation:
$k=1.15\times10^{-6}$ cm/sec x canal sediment thickness
Seepage control works: $k=1.15\times10^{-5}$ cm/sec x canal sediment thickness overlain aquifers
Grouting:: $k=1.15\times10^{-5}$ cm/sec x 1.25 thickness of wall (1 grid)
</td></tr>
</table>

(2) Result of simulation

The simulated groundwater head and flux of cases 11, 12, and 13 are delineated in in Figures 20-4.1, 20-4.2, and 20-4.3 respectively. Even though groundwater seepage is found in parts of Abo Gabal and Irad Delgaw, their main directions (vectors) are seen as aligning outwards of (toward the east and west) the main canals of Bahr Yusef and Ibrahimia.

The velocity of groundwater flow, is not so fast, with a range of 0.001～0.4 m/day, an avarege of 0.01m/day (about 4m/year). In the E-W section, groundwater is recharged from the bottom of the canals and flows outside along layered aquifers, and the runoff in the model margin flows horizontally and slightly downhill.

a) Case 11

Case 11 is prepared with a cut-off wall (or sheet piles) penetrating up to EL.25m along NDGRs’ axis. In the A-A’ section of groundwater, the equi-contour line moves downward and increases seepage amount from the canals in comparison with current seepage level (case 10). Groundwater is acted on by confined pressure from the impervious clay layer (Nc layer) overlain, and groundwater head extends outside with almost same potential from top to bottom horizon.

b) Case 12

Case 12 is prepared under the same conditions as the ongoing bank protection works designed in D/D stage, which are composed of steel sheet piles along regulator axes, upstream and downstream of regulators, and embankments on both banks (see chapter 13). The penetration depth of sheet piles is planned at EL.25m maximum at the upstream alignment, and EL.29m～EL.41m at the downstream alignment. There are 31 piling sections classified into eight depths (EL.25m～EL.41m). In the model, respective depths are given corresponding model layers.

In the section along regulator axis (A-A’), groundwater flow is defined by canal section, and seepage amount is controlled at half of that in case 11.

c) Case 13

Case 13 is prepared as case 12 plus two additional features for bank protection: grouting and seepage protection. Grouting is planned along both banks of NDGRs and seepage protection is planned on the canal floor between NDGRs and DGRs. Both aim to close the gaps in the impervious areas of the DGRs and NDGRs against infiltration.

In case 13, groundwater inference area is deduced, but its effect is much less than that in case 12.

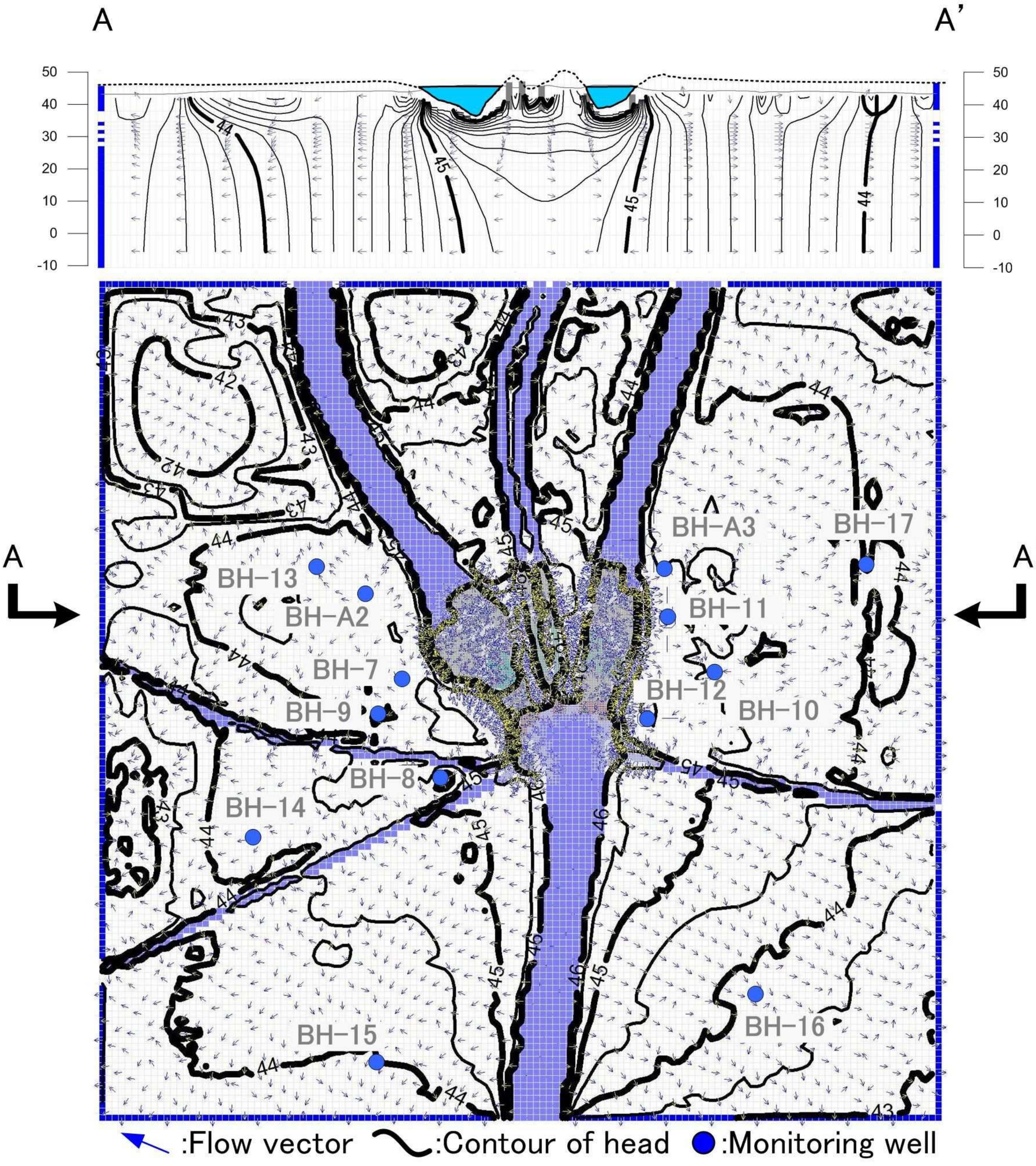


Figure 20-4.1 Groundwater head and flow vector (case 11)

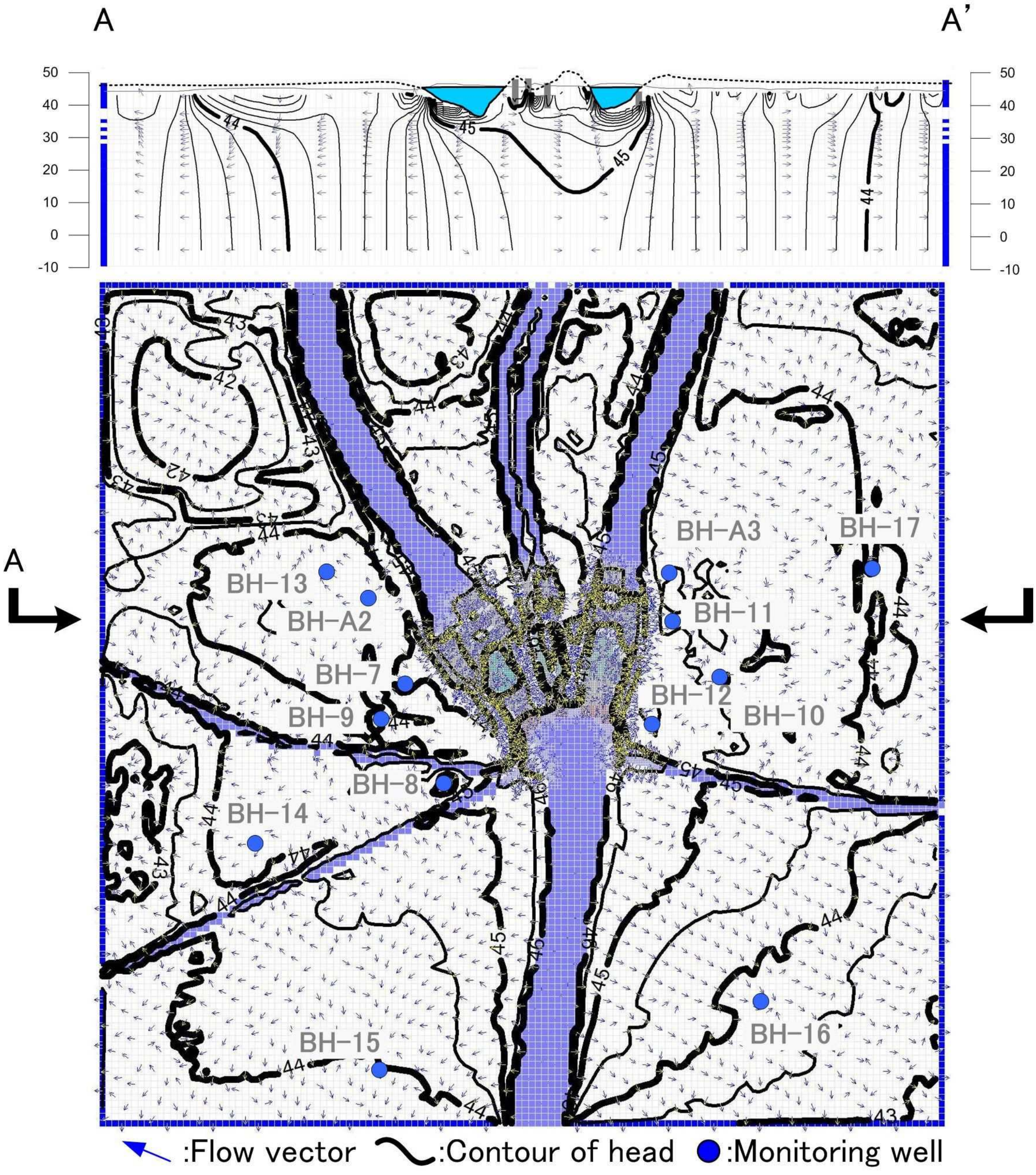


Figure 20-4.2 Groundwater head and flow vector (case 12)

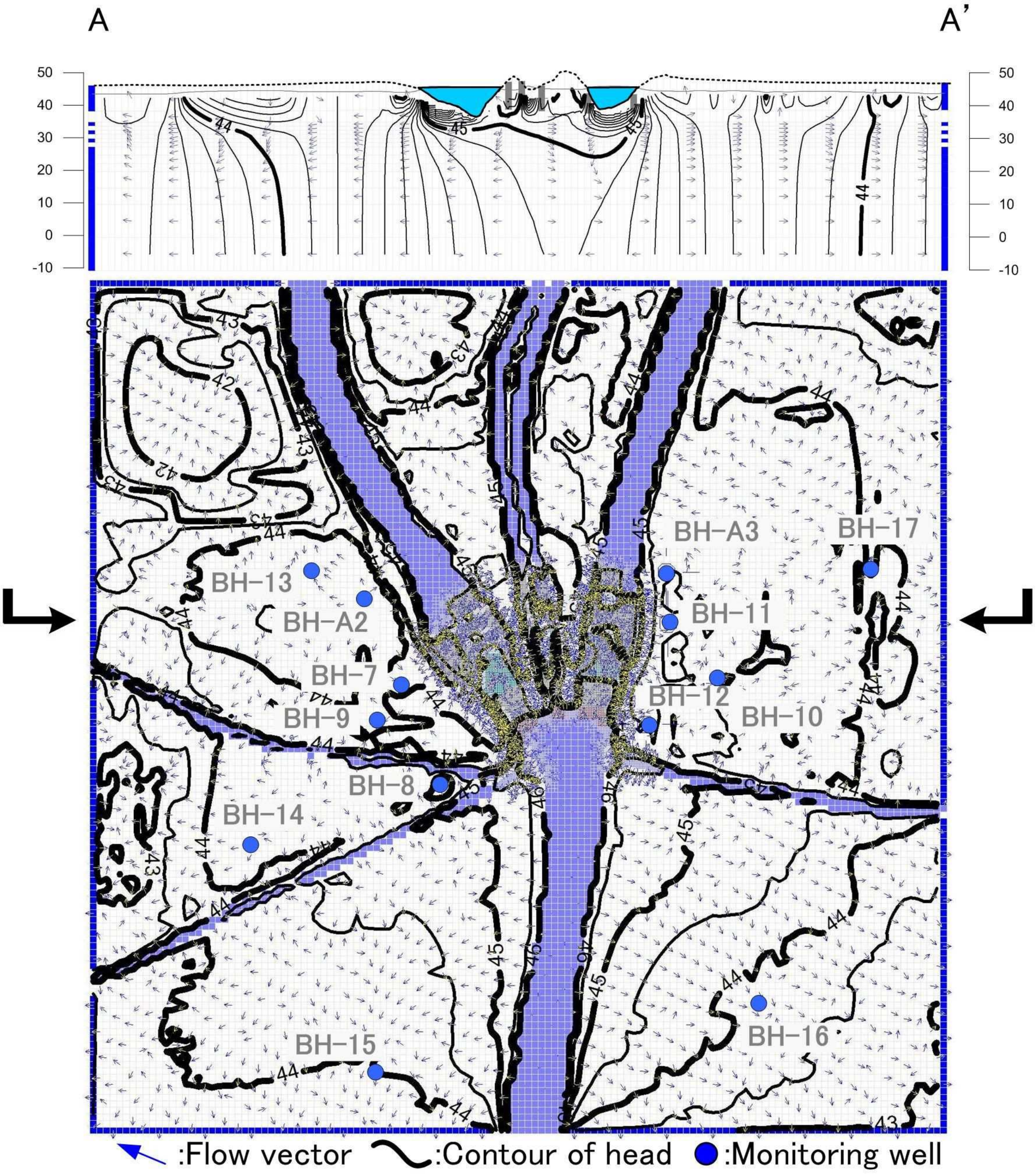


Figure 20-4.3 Groundwater head and flow vector (case 13)

20-5 Evaluation of seepage control works

(1) Groundwater rise and interference

In simulation cases 11, 12, and 13 after NDGRs construction, the rise in canal water is given as 1.3m higher than before construction at Ibrahimia canal, and 0.52m higher than before construction at Bahr Yusef canal (case 10). In the following subsections, groundwater rise and its inference is described for respective cases.

a) Case 11

In response to the canal water rise in case 11, groundwater head rises up to 0.5m on the Ibrahimia side and its influence extends with a radius of 400m from the edge of the canal water at Ibrahimia and 350m on the Bahr Yusef side. In Figure 20-5.1, the groundwater rise caused by canal water is shown as the difference between current conditions in case 10 and case 11.

Although estimated groundwater head in case 11 does not exceed ground surface, it reaches 1.25m at the shallowest point of the model range in the northwest. This depth may soak the ground surface through capillary action[13]. Areas adjoined to the canal banks, including blocks populated with shops, the railway station, mosques, and residential buildings with basements and structures on street corners are at particular risk of contact with groundwater.

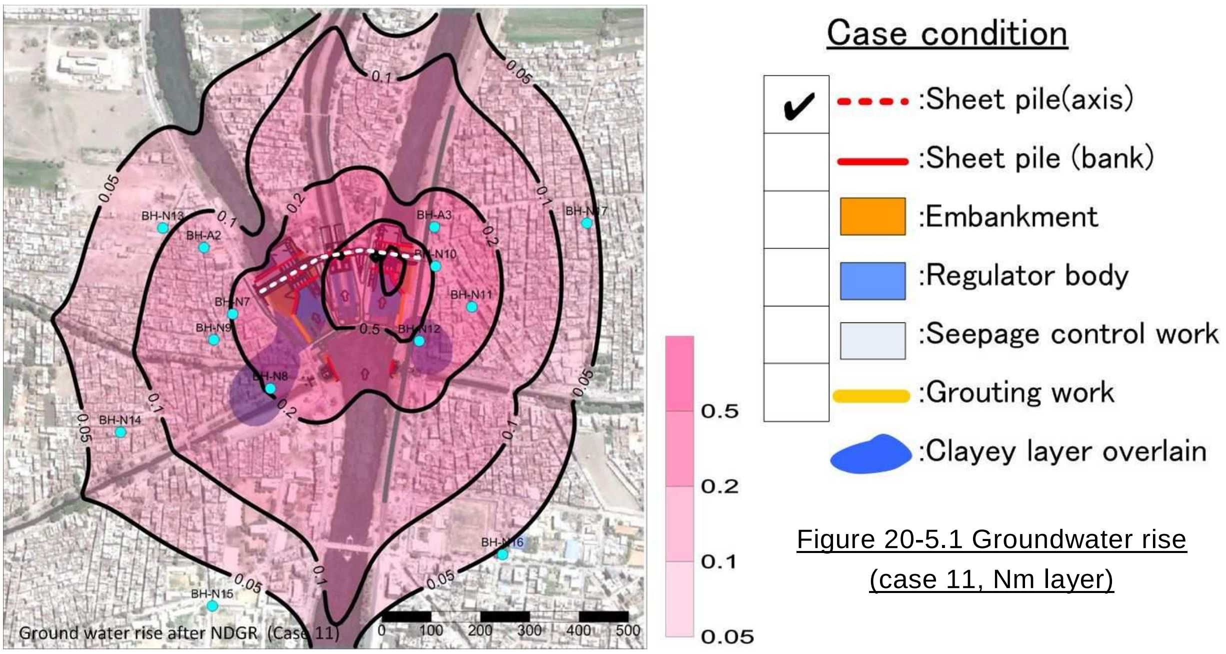


Figure 20-5.1 Groundwater rise (case 11, Nm layer)

b) Case 12

Case 12 is calculated under the condition of bank protection works designed in D/D and has enough impact on groundwater to reduce seepage by almost half of what is exhibited in case 11. In

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[13] Most of the model area is covered by clay or silt, and the silt layer exhibits soaked ground. The theoretical value of capillary rise is 150〜375cm, and wet zone may exist when the groundwater head becomes shallower than 300cm in depth according to the inventory survey.

Figure 20-5.2, the rise in groundwater (calculated as the difference in groundwater head between current condition case 10 and case 12) is shown on a contour map.

Bank protection works achieved with piling works and embankments control seepage and limit a rise in groundwater to 0.3m, and interference (of 5cm of groundwater rise) to 300m. Seepage is particularly reduced on the Bahr Yusef side through sheet piling which penetrates to the impervious horizon of the Bahr Yusef regulator’s foundation.

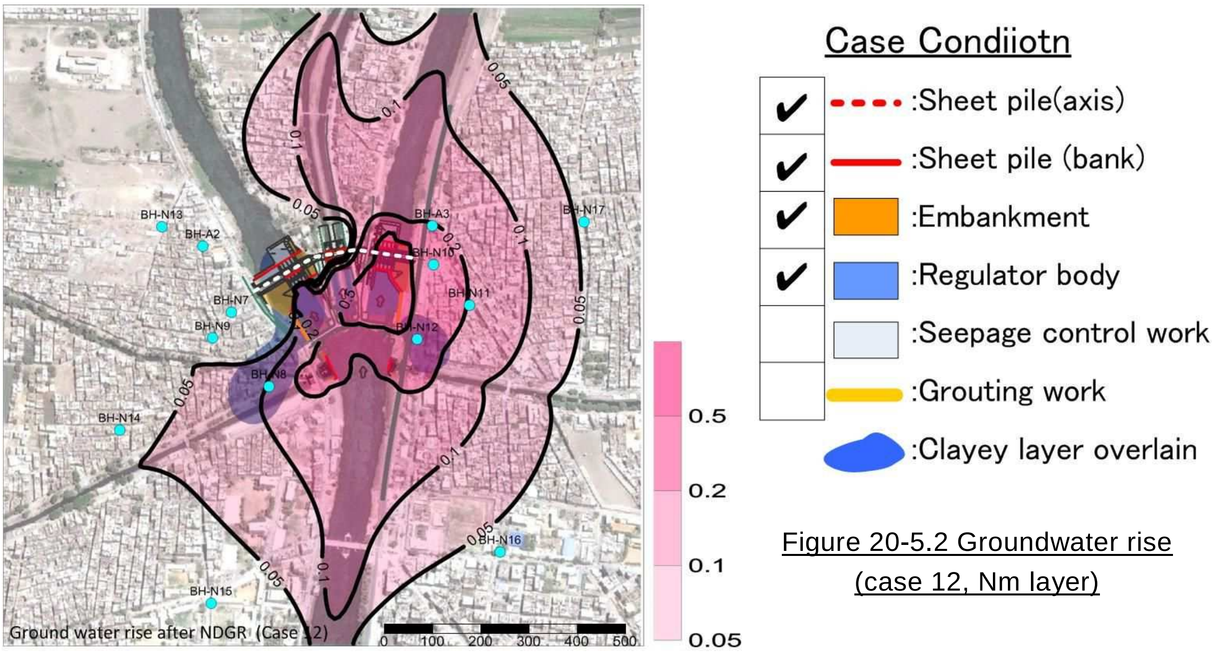

Figure 20-5.2 Groundwater rise (case 12, Nm layer)

c) Case 13

Case 13 is applied to evaluate the impact of grouting work on banks and canal bed seepage control. Therefore, model conditions and impervious properties[14] on canal floor are applied to grouting alignments.

The simulation shows that the impact of these additional works is limited and not much different from those of case 12. The range of the groundwater rise is slightly reduced and its interference range still extends to 300m, same as in case 12. The calculation results of the rise in groundwater (calculated as the difference in groundwater head between current condition case 10 and case 12) is shown in Figure 20-5.3.

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[14] Improvement target of grouting is set as 1x10^{-5}cm/sec since grouting section is mainly composed of sandy foundation. The canal floor is also subjected to same condition of permeability.

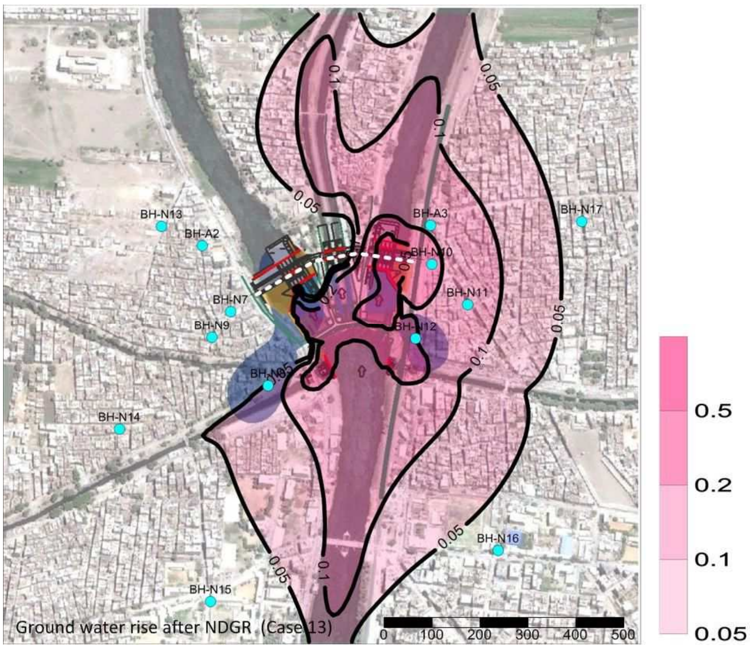

Figure 20-5.3 Groundwater rise (case 13, Nm layer)

(2) Comparison of seepage control works

The comparison Table 20-5.1 evaluates these two alternate plans; case 12 (bank protection work with steel sheet pile) and case 13 (case 12 plus grouting and seepage control on canal floor).

Table 20-5.1 Comparison of the seepage control works

Case	Feature of construction works			Effectiveness		
	Additional works	Reliability for quality	Temporary works	Groundwater rise	Inference area	Seepage amount
Case 12 bank protection	None ○ Done as bank protection	Certain ○ Sheet pile, embankment	None ○ Done as bank protection	0.09 m Avg. for model area	300m (RB) 270m (LB)	39m^3/day Avg. from all canals
Case 13 bank protection/ grouting/ seepage control	Necessary × (grouting, seepage control for channel beds)	Uncertain △ (difficult target)	Necessary × Expanding construction yard	0.06m Average for model area	300m (RB) 290m (LB)	33m^3/day Avg. from all canals

Case 13 presents obstacles to the course of NDGRs construction. Practically, grouting work has to be carried out after regulator construction to ensure sufficient workspace for construction. Also, earth works on the canal floor require temporary bypassing work before construction. The cost of construction therefore increases, and the construction period is extended.

Even if the works required in case 13 were completed, seepage control is much more effective in case 12. As for the differences in the results between case 12 and case 13; groundwater rise difference is only 0.03m, and difference in groundwater inference distance is 30m maximum and seepage amount is 6m^3/day. Case 13 is therefore considered an ineffective plan due to the high cost of construction.

Although case 12 was solely designed for bank protection work, it also functions as groundwater control (water rise can be suppressed by a maximum of 0.3m), and restricts the expansion of risk to foundational and underground structures[15] to less than 3% (see Figure 20-5.4).

From both an environmental and an economical perspective, analysis shows that case 12 is the most feasible.

(3) Groundwater depth after NDGRs construction in case 12

In Dirout city, wet ground is caused by leakages from water supply pipes and sewage inlets. However, it may also be indirectly facilitated by the rise in groundwater due to inflow from canals and sewage water. In Dirout city, the underground structures of the most recent buildings are built 3m from the surface to avoid the harmful effects of shallow groundwater. Alternately, if groundwater level is kept deeper than GL -3m[16], negative environmental impacts can be evaded.

To check spatial distribution and risk inclination after the construction of the NDGRs (case 12), risk area is calculated with management depth, defined as GL-3m, as shown in Figure 20-5.4. Risk areas are spread widely at the low plains around NDGRs. In Figure 20-5.4 ‘blue’ indicates a risk area in the current condition (case 10), while ‘red’ indicates an expanding area after NDGRs’ construction (case 12). However, these risks only present themselves from June to August, the season with the highest water levels. As there are multiple factors influencing these phenomena, groundwater monitoring is to be continued with the purpose of facilitating impact mitigation projects, such as a public sewage system and so on.

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[15] The drawing shows a risk area for groundwater obstacle due to shallow groundwater head which is less than marginal depth (3m from GL) at highest season. The ‘blue’ areas are the current risk area (case 10), while ‘red’ shows an expanding risk area after NDGRs construction (case 12).

[16] In general, management depth for underground facility is set as GL-3m to keep enough distance for controlling the groundwater rise by soil capillary action, and successive leaching.

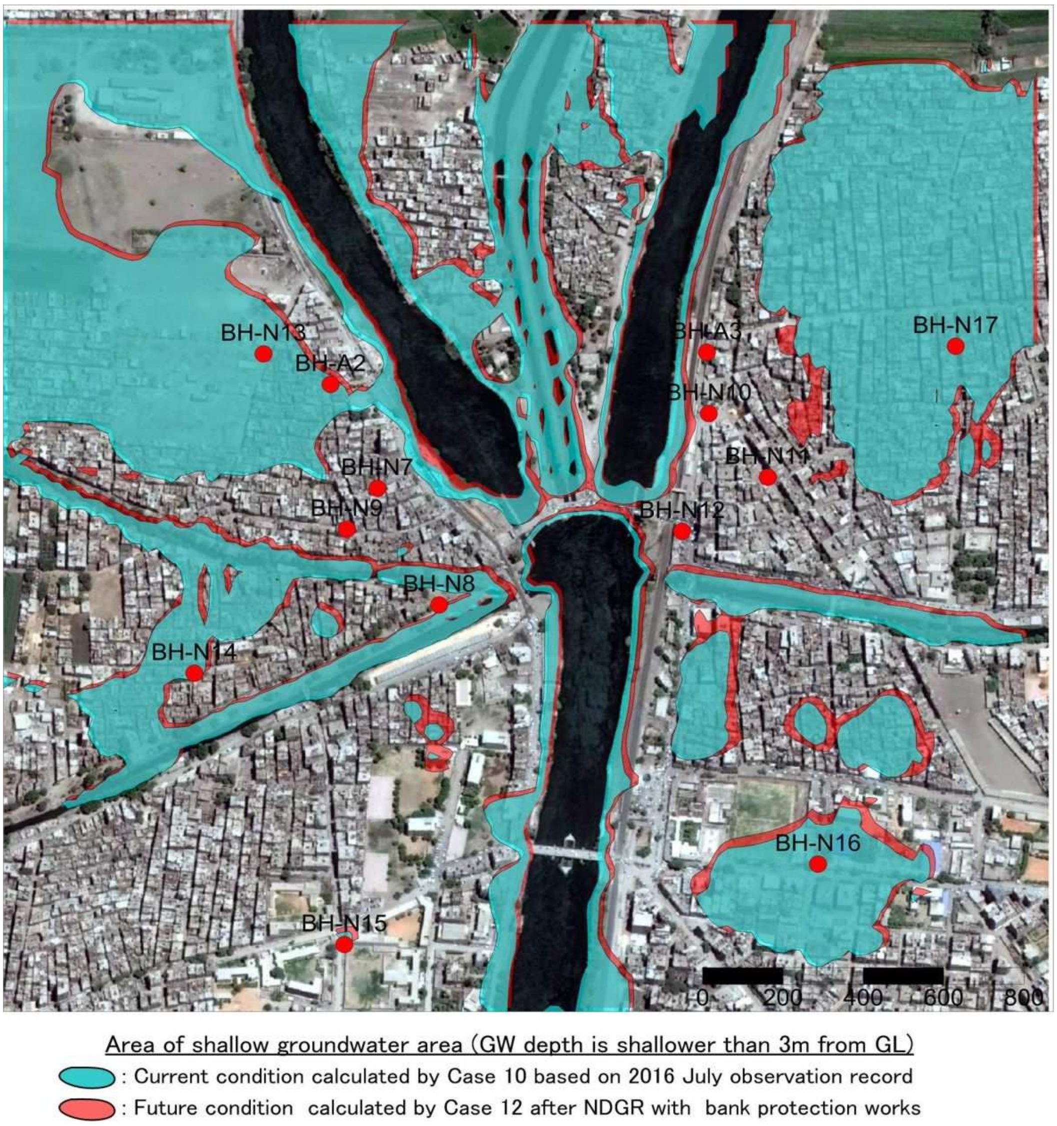
BH-N13
BH-A2
BH-N7
BH-N9
BH-N8
BH-N14
BH-N15
BH-A3
BH-N10
BH-N11
BH-N12
BH-N17
BH-N16
0
200
400
600
800
Area of shallow groundwater area (GW depth is shallower than 3m from GL)
🟦 : Current condition calculated by Case 10 based on 2016 July observation record
🟥 : Future condition calculated by Case 12 after NDGR with bank protection works

Figure 20-5.4 Area of shallow groundwater head (less than 3m from GL)

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Volume II–WATER MANAGEMENT SYSTEM

1. Integrated Water Management System

1-1 Background of integrated water management system

The DGRs distribute 9.6 billion m^3 of irrigation water per year from the Nile River to approximately 600,000 hectares of land via the Ibrahimia canal. The water is distributed to the beneficiary areas by seven canals originating at the group of regulators. Of the seven canals branching from the group of regulators, the Bahr Yusef and Ibrahimia canals are 300km long, and as such are the main canals. Bahr Yusef canal has four regulators (Lahoun, Mazoura, Sakoula, and Dahab) installed with grant aid from Japan, and were upgraded between 1995 and 2010.

The DGRs were built in 1872, and the hydraulic functions of the facilities have declined significantly since then due to age. If the group of regulators is upgraded to enable them to fulfill their essential hydraulic functions, water can be properly distributed to the seven canals. The integrated operation of the group of regulators and the four regulators already installed will improve irrigation in the middle reaches of the Nile, leading to efficient water resource management in the area. Integrated operation and management of the group of regulators and the major regulators, will allow for appropriate water distribution in five governorates (Assiut, Giza, Beni Suef, Fayoum, and Minia).

Water management in the covered 600,000 hectares, is managed by the General Directorate for Water Distribution (GDWD) in Assiut. This authority manages the DGRs and the regulators on the canals that are located on the governorate boundaries. GDWD in Assiut monitors the regulator gates and instructions on gate operation through the General Directorates of Irrigations (GDIs). GDI monitor and instruct the gate operation to the intermediate regulators (not on the governorate boundaries) and the branch canals for water distribution.

To ensure proper water distribution to the canals, upgrading the DGRs is vital to stabilize the water level in the canals, with the aim of diverting the water taken in at the Ibrahimia Head regulators in the seven directions with prescribed amounts. Water management is particularly important in stabilizing water levels at canals over 300km long (Bahr Yusef and Ibrahimia canal), and diverting the prescribed amounts of water to the branch canals upstream of the regulators.

Furthermore, in order to let the diverted water from the main canals to the branch canals reach to the end fields, it is important to eliminate sediment blockage to the flow in the branch canals, and to let even the minor irrigation facilities give adequate hydraulic functions. However, the deteriorated minor irrigation facilities and gates do not adequately fulfill their hydraulic roles, resulting in defective canals and irrigation facilities and causing water shortages at the fringes of the beneficiary areas.

To ensure proper water management from the main canals to the ends of the branch canals across a huge beneficiary area of approximately 600,000 hectares , it is important to break down the issues and clearly define the steps necessary for: (1) upgrading the main regulators on the main canals, (2) introducing a water management system capable of providing centralized wide reaching water management, and (3) upgrading the facilities to restore the hydraulic function of the canals and minor irrigation facilities.

Downstream water level control~~s~~ system has generally been used to manage gate operation of regulators in Egypt until now. Therefore, introducing a new water management method that maintains stable water levels upstream and stable water distribution with an over-flow type gate, will require a trial period and technical assistance. Considering these changes, the following steps can promote fair water distribution in the areas concerned.

Step 1:

- Construction of new DGRs
- Introduction of an integrated water management system

Step 2:

- Technical assistance and aid for Integrated water management system

Step 3:

- Upgrading narrowed canal sections and minor irrigation structures to ensure proper water distribution

1-2 Concept of integrated water management system

In order to distribute the diverted irrigation water to the beneficiary areas fairly and properly, an integrated water distribution system should be established to monitor irrigation water diversion and formulate a proper water diversion plan. The objectives of the integrated water distribution system are the monitoring of water diversion and the evaluation of flow situation at (1) the new DGRs, (2) regulators along the Bahr Yusef canal and the Ibrahimia canal, and (3) intake facilities of branch canals, in order to formulate a real-time water distribution plan.

These things are realized by introducing unified management of the water distribution status at each monitoring location utilizing the telemeter system through flexible water management, rational water distribution based on the balance of supply and demand of water volume and fair water distribution management. The concept of the integrated water management system to be introduced in the study is consistent with that of the Central Directorate for Telemetry. With reference to the points above mentioned, the concept of the water management system will be established by introducing instruments and equipment that realize fairness, reliability, and flexibility of the system.

Table 1-2.1 Basic concepts of water management system

Description	Expected Accomplishment
Fairness	-Fair water distribution management under the prescribed amounts of water
Reliability	-Effective water distribution management reflecting the arrival time of supply -Appropriate water distribution based on the cropping schedule -Effective water distribution due to the reduction of management loss
Flexibility	-Water management corresponding to a future’s change of cropping pattern -Flexible water management based on the balance between demand and supply

In order to realize the integrated water management system, it is important point that not only installation of water distribution equipment but also human resource development for operating these equipment. Since the operation and maintenance manual for water distribution instruments will be prepared in the study, it will be utilized for future human resource development through the Technical Cooperation Project, and as such must establish the following basic functions.

Table 1-2.2 Three basic functions of the project

Item	Contents
Real-time Water management	Real-time monitoring of water supply situation in NDGR, discharge situation of each regulator in canal and the main branch canal intake.
Water Balance Management	Realization of unified monitoring of the discharge at the regulators and branch canal intake. And that the water balance can be confirmed at the central monitoring room by comparing "difference discharge between upstream and downstream regulator" and "demand amount multiplied by unit water requirement and served area".
PDCA Cyclic management	Formulate an improved cycle: Plan, Do, Check, and Act of water distribution system cycle. Proper water distribution and the rapid improvement of evaluation results based on real time discharge data are expected.

2 Current Situation of Water Distribution System

2-1 Regulators along main canals

The locations and names of the regulators on Bahr Yusef canal and Ibrahimia canal are shown in Figure 2-1.1 and Table 2-1.1. There are four regulators on Bahr Yusef canal and eight on Ibrahimia canal.

The role of the regulators on the governorate boundaries is to send the obligatory discharge to the governorate downstream. These play an important role in water management on the long main canals. The role of the other regulators except on governorate boundaries is to maintain water level at the main canals and stabilize diversion to the branch canals. At the regulators located on governorate boundaries, an H-Q curve is created on the downstream side of the regulator.

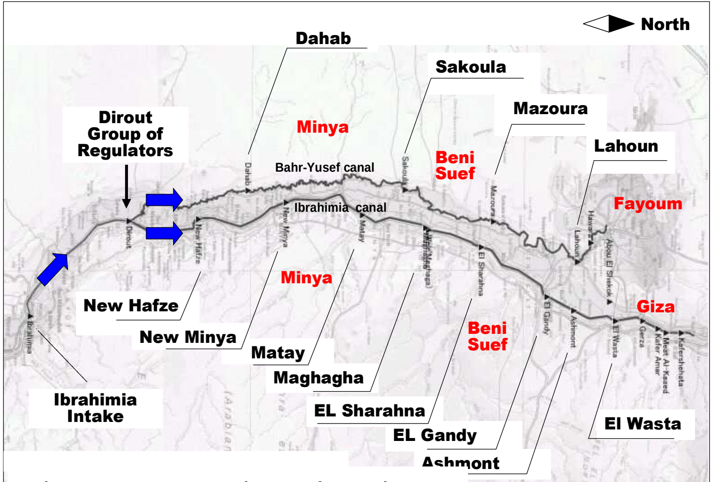


Figure 2-1.1 Locations of regulators

Table 2-1.1 Regulators along the main canals

Name of Canal	Regulator	Location	District Boundary	Gate Type		
				(1)	(2)	(3)
Bahr Yusef canal	Dahab regulator	Minia		+		
	Sakoula regulator	Minia	Beni Suef	+		
	Mazoura regulator	Beni Suef		+		
	Lahoun regulators	Beni Suef	Fayoum	+		
Ibrahimia canal	New Hafez regulator	Minia			+	
	New Minia regulator	Minia			+	
	Matay regulator	Minia			+	
	Maghagha regulator	Minia	Beni Suef		+	

	El Sharahna regulator	Beni Suef				+
	El Gandy regulator	Beni Suef				+
	Ashmont regulator	Beni Suef				+
	EL Wasta regulator	Beni Suef	Giza			+

Note: Gate Type (1) is double leaf gate, (2) is chain type, (3) is Fahmy Henien gate

Source: JICA Study Team (2015)

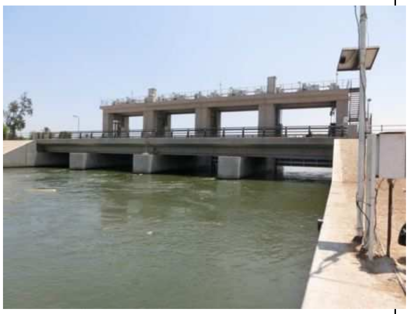
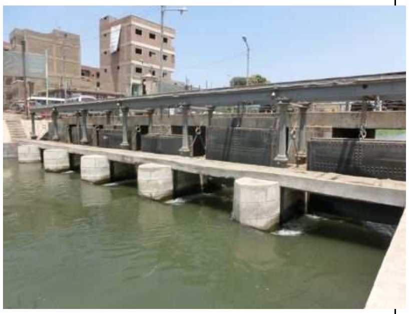
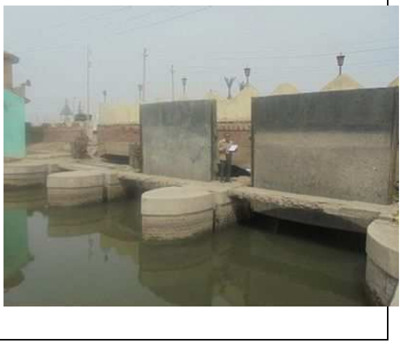
Double leaf gate	Chain type gate	F.H.(Fahmy Henien) gate
		

Figure 2-1.2 Regulators' gate type

Regarding the water level condition of each regulator, the water level status at the time of F/S, which became the background of implementation of the Project, is shown in Figure 2-1.3.

The regulator's gate operation aims to maintain a consistent water level downstream of the regulators along the Bahr Yusef and Ibrahimia canals. The typical fluctuations of water level at some regulators are shown in Figure 2-1.3 as an example. At Sakoula and Mazoura regulators, upstream water level is maintained in order to distribute water from the main canal to the branch canals. However, keeping the water level stable except summer months has become impossible. As for the regulators along the Ibrahimia canal, the upstream water level at the New Hafze Regulator is maintained high enough for reliable diversion to the Serry canal located upstream of the New Hafze Regulator.

As for the other regulators along the Ibrahimia canal, there is no major difference in the water level between the upstream and the downstream, as shown in the following figure (Matay regulator).

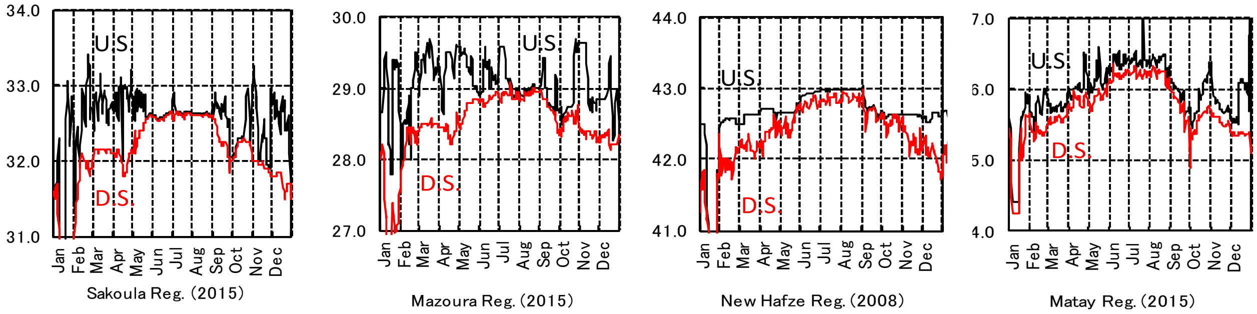


Figure 2-1.3 Record of U/S and D/S water levels at regulators along Bahr Yusef and Ibrahimia canals

Based on the current situation above mentioned, the challenges and measures for better water management along the main canals are shown in Table 2-1.2.

Through interviews with the GDWD in Assiut and GDIs, some of the regulators along the main canals are operated to maintain upstream water level for the branch canal intakes.

On the other hand, other regulators especially those located along the Ibrahimia canal are operated to maintain downstream water level. As will be described later, the GDWD in Assiut is located far from the actual operation sites. Therefore, the GDWD in Assiut could not monitor the gate operation status of the branch canal, such as whether or not the appropriate amount of water is distributed to the branch canal. And interviewing through this survey, there are subsequent concerns regarding excessive intake from the branch canal intake on the upstream side. For implementing appropriate water distribution, it is GDIs that operate the regulator along the main canal directly, and the GDWD in Assiut is the only institution that monitors the status of water distribution.

Table 2-1.2 Challenges and future countermeasures for main canals

Location	Challenges	Countermeasures
Regulators along Bahr Yusef canal	Lacking gate operator monitoring and follow up activities causes big water level fluctuations at regulator upstream	Operational guidance of gate to stabilize the upstream water level, and supervise branch canal's intake
Regulators along Ibrahimia canal	Because the difference between upstream and downstream water levels at regulator is small, the water intake to branch canal is not stable except at New Hafez regulator	Operational guidance for regulator's gate operation along main canal, and supervision of branch canal's intake

2-2 Small scale irrigation facilities (branch canal intake)

Under the current water management system, the roll of regulators located on the governorate boundaries is to discharge the proper amount of water to the downstream governorates. However, the quantities demanded for irrigation covered by each regulator are not distributed evenly to the branch canals.

In order to establish a proper water management system, it is important to take proper amount of water from the main canals to the branch canal and to operate the gates based on planned or actual demand. However, some of the gears of intake gates in the branch canals have broken (caused by deterioration and the theft of gear parts). As a result, the GDIs in charge of the gates operate the intake gates using a makeshift temporary steel frame attached to a mobile hoist or lifts up the gates by backhoe to divert water to the branch canals. There are some spots on the branch canals where the flow capability declines due to sediment accumulation and discarded rubbish. In the future, measures will be taken to ensure proper water distribution to the branch canals, such as installing water gauges that enable remote checking of flow conditions of the branch canals.

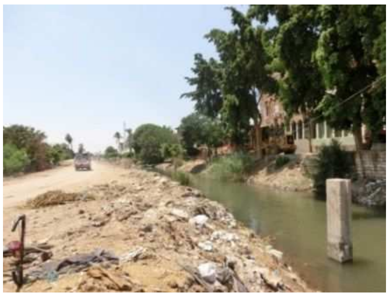
West Hafez Ganabia intake	El Mansour intake	Secondary canal after intake gate
		
The gear was broken. The gate is lifted and operated by chain crane and temporary steel frame.	The gear was broken. Lifting up the gates by backhoe as a temporary measure to divert water to the branch canal.	The flow capability declines due to sediment accumulation and discarded rubbish at the head of branch canal.

Figure 2-2.1 Gates with non-operational hoist and condition of branch canal

Table 2-2.1 Challenges and future countermeasures for minor irrigation facilities

Irrigation facilities	Challenges	Countermeasures
Branch canal's intake	The gate has not been operated, partially because some gears have been broken and others stolen. Irrigation district staff operates the gate by temporary mobile crane.	Replacement of the gate by Irrigation Directorate
Canals	Cross section of canal has been narrowed by sedimentation of soil and garbage, and water flow has been obstructed by sediment soil. On the other hand, there are some branch canals where the cross sections are over dredged.	Reshaping of the branch canals cross section by Irrigation Directorate.

2-3 Current situation of gates on branch canals

The field survey of the branch canal intake on the Bahr Yusef and Ibrahimia canals had carried out. The purpose of the survey was to clarify the current condition of the branch canal's intake. The branch canals surveyed were selected based on selection criteria described in section 3

In addition, the Minia and Beni Suef directorates had also implemented the current gate conditions of the branch canal's intake. These data were compared with the field survey result by D/D consultant and updated in accordance with that of the D/D consultant.

According to the survey by the D/D consultant, deterioration is progressing with fifteen gates and it is judged that all gates are in need of rehabilitation work for smooth and timely gate operation. The evaluations are shown in Table 2-3.1. In the column "defect condition," "A" means the stuck F.H. gate with gear trouble, and "B" means that the gate is operated by a temporary mobile hoist.

The rightmost column in Table 2-3.1 shows the relationships of the selected 128 minor structures that were inspected during the feasibility study of Dirout Group of Regulators in 2010. "-" in the column means that the target branch canals to be monitored in this NDGRs project are not included in the selected irrigation facilities at F/S which need rehabilitation.

During F/S study stage, the selected 128 minor structure had been prioritized for rehabilitation and those rehabilitation works would have been implemented by RGBS, however, the rehabilitation works are still under consideration at the moment. D/D consultant proposes to take up the following 15 intakes for reconstruction because they are important for the appropriate distribution of irrigation water from the main canal to the branch canal.

Table 2-3.1 Gate conditions at branch canal's intake

Name of Main Canal	Name of Branch Canal	Gate Type	Condition (Data from Directorate) 1: good 2: need maintenance	Condition (Inspection) 1: good 2: need maintenance	Defect condition	Selected 128 Minor structure
Bahr Yusef canal	Manshat EL-Dahab	F.H.	1	2	A	-
	El-Hareka	F.H.	1	2	A	-
	El-Sabaa	F.H.	1	2	A	-
	Quftan	F.H.	2	2	A	-
	Wesh El-Bab	F.H.	n/a	2	A	-
	El Giza	D.L.	n/a	1	-	-
	Hassan Wasef	D.L.	n/a	1	-	-
	New Kamdeer P.S.	Pump	n/a	1	-	-
	New Terfa P.S.	Pump	n/a	1	-	-
	Old Terfa P.S.	Pump	n/a	1	-	-
	Old Sakoula P.S.	Pump	n/a	1	-	-
	Mazoura P.S.(2)	Pump	n/a	1	-	-
Ibrahimia canal	Irad El Maharak	F.H.	n/a	2	A	-
	El Kosia	F.H.	n/a	2	A	-
	East Hafez	F.H.(with crane)	1	2	B	-
	West Hafez	F.H.(with crane)	2	2	B	-
	Adkak	F.H.(with crane)	1	2	B	-
	Gendia	F.H.(with crane)	2	2	B	-
	EL Soultany	F.H.	2	2	A	-
	Tansa	F.H.	1	1	-	-
	EL Azhary	F.H.	2	2	A	-
	Bosh	F.H.	2	2	A	-
	El Mansour	F.H.	2	2	A	-
	Serry Weir	Weir	-	-	-	-
	Maghagha Weir	Weir	-	-	-	-
	Abo Shosha Weir	Weir	-	-	-	-
	Bani Hader Weir	Weir	-	-	-	-

F.H. Fahmy Henien gate
D.L.: Double leaf gate
F.H. (with crane): The gate which is lifted up by chain crane.

2-4 Water management and distribution at DGRs

According to the interview with the CDWD during the F/S stage in 2010, water management and distribution for each governorate are based on the Agreement of Water Distribution approved by the governorates in 2002. However, it is clarified that this Agreement has not been taken into account for recent years. The water distribution is evaluated based on the data recorded by CDWD. Table 2-4.1 and Table 2-4.2 show the distributed amount of water and intake ratios from Bahr Yusef and Ibrahimia canals.

Table 2-4.1 Distributed water amount (average from 2010 to 2014)

Distributed Area		Discharge (MCM) *	Ratio (%)
Ibrahimia Head regulator		8,969	100%
	Bahr Yusef at DGR	4,566	51%
	Ibrahimia at DGR	3,399	38%

Source: CDWD's daily recorded data arranged by JICA Survey Team

*: Total discharge from February to November during 2010-2014

Table 2-4.2 Distributed water amount at Bahr Yusef and Ibrahimia canals (DGRs, average from 2010 to 2014)

No	Directorate	Bahr Yusef canal			Ibrahimia canal		
		Discharge (MCM) *		Ratio (%)	Discharge (MCM) *		Ratio (%)
DGR		4,566		100%	3,399		100%
	Minia	(1)	808	18%	(5)	1,871	55%
	Beni Suef	(2)	601	13%	(6)	1,528	45%
	Fayoum	(3)	2,493	55%			
	Giza	(4)	664	15%			

Source: CDWD's daily recorded data arranged by JICA Survey Team

*: Total discharge of February to November during 2010 – 2014

(1)= 4,566MCM (Discharge at DGR)-3,758MCM (Sakoula)

(2) = 3,758MCM (Sakoula)-1,461MCM (Lahoun)-1,032MCM (Hassan Wasef)

(3) =1,461MCM (Lahoun)+1,032MCM (Hassan Wasef), (4) = 664MCM (Giza Intake)

(5) = 3,399MCM (Discharge at DGR)-1,528MCM (Maghagha Weir)

(6) = 1,528MCM (Maghagha Weir) for Beni Suef and Giza

2-5 Irrigation system schematic diagram

In order to grasp the water distribution condition on the branch canals, a review was made on the command area of each branch canal surveyed during the F/S stage. The irrigation system schematic diagram is shown in the appendix.

2-6 Changes in water level of Lake Quarun

Figure 2-6.1 shows the record of water level of Lake Quarun in Fayoum Governorate. The lake is situated at the end of Bahr Yusef canal and the canal is only the lake's water source. Therefore, the cause of lake's water level rise are thought to be due to ineffective discharge from Bahr Yusef canal.

According to the water level data from 2010 through 2011 the rise in water level was temporarily curbed. However, since 2012 the level has begun to rise again. As there are hotels on the shore of Lake Quarun, water level rise should be avoided. In order to curb the rise, it is necessary to reduce ineffective discharge from Bahr Yusef canal and to use irrigation water more effectively.

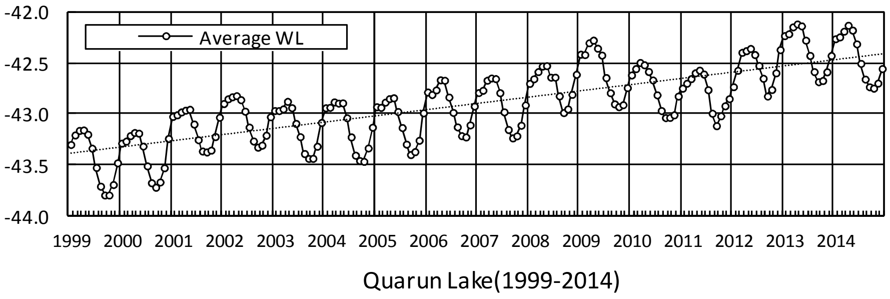


Figure 2-6.1 Water level changes of Lake Quarun

Quarun Lake

Water Level Monitoring Facility

Figure 2-6.2 Lake Quarun and water level monitoring facility

2-7 Telemetry system

(1) MWRI‟s Policy of telemetry system

The CDT of MWRI has implemented a telemetry system since 2009. The purpose of the telemetry system is to “transmit water level data at regulators, pump status, discharge data and meteorological data to the departments and agencies concerned with water distribution in real-time” and to “evaluate distribution to each governorate.” The system aims to compare actual and planned water distribution in each governorate according to CDT policy, and to set up the system to adjust the water distribution in each canal based on the monitoring data. The main function of supervisory in the telemetry system is located in the CDT as the main station. At present, 219 gauging stations have been established. The equipment of the gauging station is composed with a water level sensor, a data logger with RTU, a GPRS modem, a solar panel, a charging controller and battery. The water level, voltage, and temperature data are transmitted to the main server every hour and then automatically sent to the GDWD and the GDI in each governorate in hourly text-typed e-mails. The water level data is also sent to the MWRI. In the future, MWRI plans to (1) increase the number of gauging stations to 450 with it’s five year plan, (2) add discharge and flow velocity data to the transmitted water data, and (3) upgrade the system capable of optimizing water distribution to each governorate by evaluating the water balance between supply and demand.

The outline of the telemetry project (the water management system diagram formulated by the CDT) is shown in Figure 2-7.1.

The vast quantity of data collected through the telemetry monitoring equipment should be taken into a system as simple as possible. This should enable non-professional persons to grasp changes in water levels and other conditions easily.

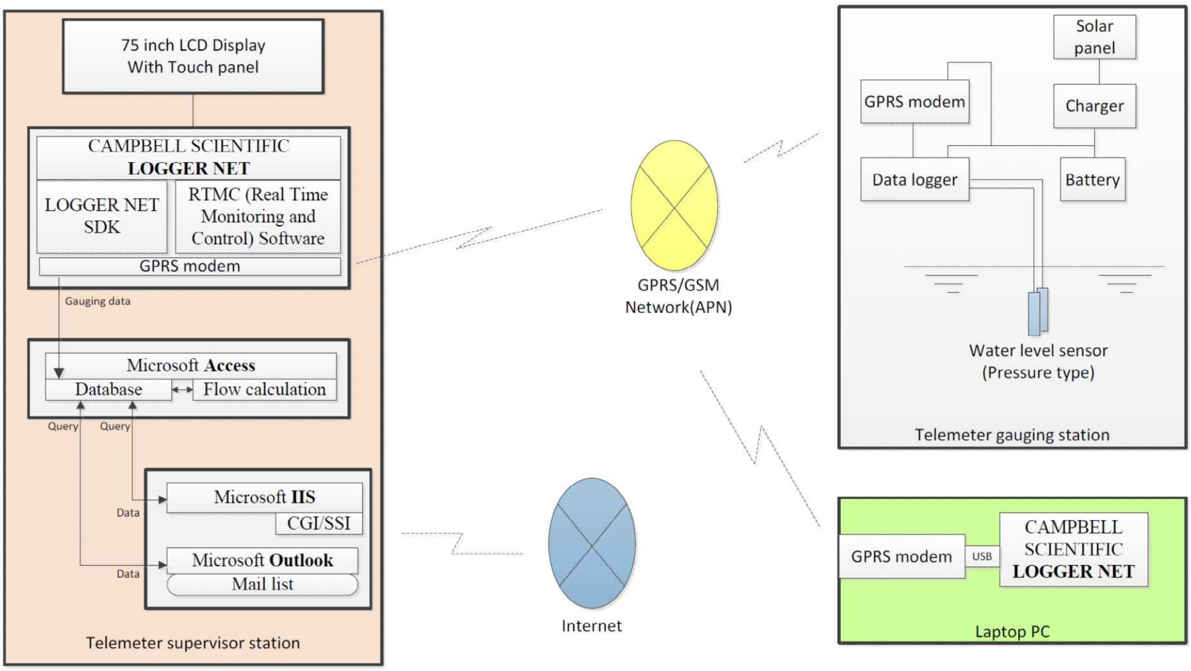
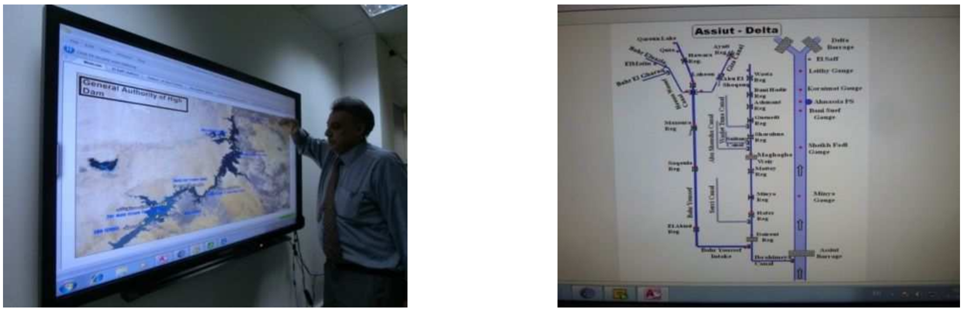


Figure 2-7.1 Schematic diagram of existing water monitoring system


Telemetry system in Cairo

Schematic Diagram of Dirout Area

Figure 2-7.2 Existing telemetry system, CDT in MWRI

(2) Telemetry sites in the project area

CDT has laid out the telemetry system in the project area. Table 2-7.1 indicates the names of telemetry sites which have been installed by CDT. Eleven sites have the H-Q curve equation for converting discharge based on downstream water level

Table 2-7.1 Current conditions of telemetry sites in the project area

Irrigation facilities			Name of the target facilities	Water Level		H-Q Curve	Number	
				Up	Dw		WL	H-Q
Dirout group of regulators			Bahr Yusef regulator	+	+	+	2	2
			Ibrahimia regulator	+	+	+		
Regulator	Bahr Yusef canal		Dahab regulator	+	+		6	3
			Sakoula regulator	+	+	+		
			Mazoura regulator	+	+			
			Lahoun regulator	+	+	+		
			Abo El Shekok regulator	+	+	+		
			Regulator km39	+	+			
	Ibrahimia canal		New Hafze regulator	+	+		1	0
Branch canal	Bahr Yusef canal	Intake	El Giza	+	+	+	1	1
		Weir	Hassan Wasef Weir	+	+	+	1	1
	Ibrahimia canal	Weir	Maghagha Weir	+	+	+	1	1
Ibrahimia main canal			Ibrahimia Head regulator	+	+	+	1	1
Lake			Quarun Lake	+			1	0
Total							14	9

Source: Central Directorate for Telemetry

2-8 Current monitoring and operating system

(1) Current method of water management

The current water management method is the same as that of generally used in Egypt, and local expertise on water management has accumulated for many years. On the other hand, it has become difficult to respond flexibly to the current water demand, caused by the diversification of farmland operation, and for real-time adjustment of water distribution based on the demand, for effective use of water resources and swift mobility for necessities in the ages

In addition, the demand for visual water distribution management has been raised with the increase of demand and interest of farmers and a strong need for an equal and appropriate water distribution system that responds to water demands in real time. This can be made possible with the development of highly-extensible and low-cost telemetry stations set up by MWRI.

(2) Organization responsible for water management system

The organization mentioned below is served for the monitoring of (1) water levels at the regulators along the main canal in the project area, and (2) the operation of regulator gates.

i) General Directorate for Water Distribution (GDWD) in Assiut

ii) General Directorates for Irrigation (GDIs) in Assiut, East Minia, West Minia, Beni Suef, Fayoum, and Giza

iii) Gate operators of each regulator

Figure 2-8.1 shows the instruction flowchart on gate operation of each responsible organization. Also, Table 2-8.1 shows the monitoring items at each regulator and the responsible organization of each regulator.

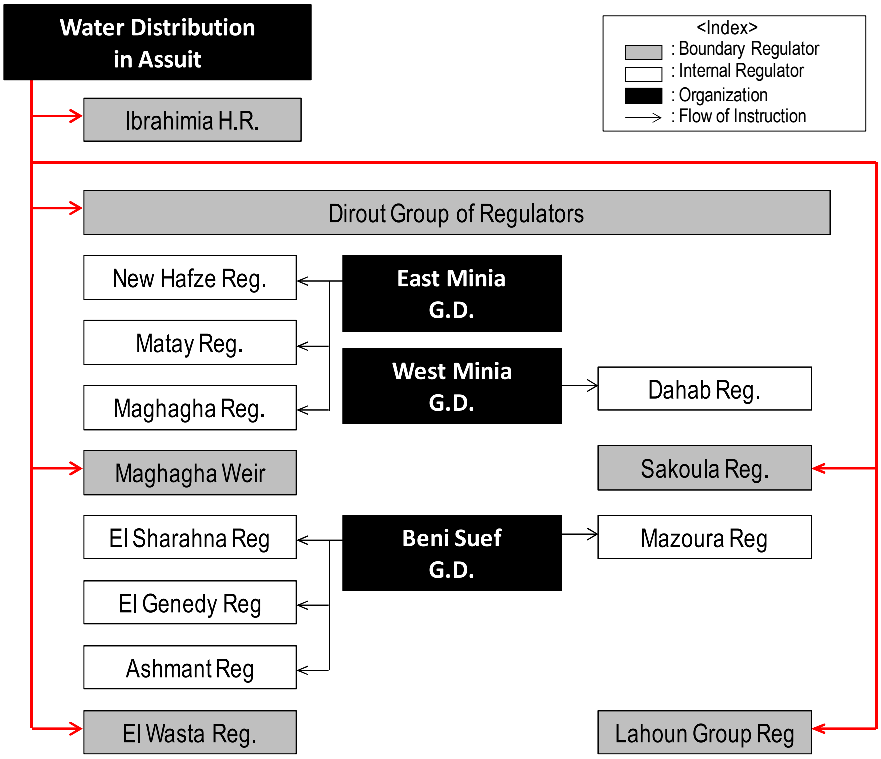


Figure 2-8.1 Organizations chart for the management of each regulator and gate operation

Table 2-8.1 Monitored items and organization responsible for the operation at each regulator

		Monitoring		Instruction Organization			
		Water Level	Dis-charge	WD in Assuit	East Minia	West Minia	Beni Suef
Ibrahimia Head Regulator		+	+	+			
Dirout Group of Regulator		+	+	+			
Bahr Yusef	Dahab	+				+	
	Sakoula	+	+	+			
	Mazoura	+					+
	Lahoun group	+	+	+			
Ibrahimia	New Hafze	+			+		
	Matay	+			+		
	Maghagha	+			+		
	Maghagha Weir	+	+	+			
	El Sharahna						+
	El Gendy						+
	Ashmant						+

As shown in Table 2-8.1, GDWD in Assiut is responsible for water distribution in the project area. The regulators between the governorates are monitored by the telemetry system and data are transmitted to the CDWD, the GDWD in Assiut, and the GDIs on time. At the other regulators on the main canals, Bahari, i.e. the gate operator, reads the water levels upstream and downstream of the regulators three times a day, and reports to the GDIs via mobile phone. After receiving the reports from the gate operators, GDIs informs the GDWD in Assiut of the water level data via mobile phone. Then, the GDWD issues instructions on the water level settings only on the downstream side of the regulators at the governorate boundaries (boundary regulators) to GDIs and the gate operators of these regulators adjust the gates in accordance with the instructions

GDIs decide on the water levels at the intermediate regulators (not on governorate boundaries) independently, and issue instructions to the gate operators. Observed water level data is converted to discharge (by H-Q curves) only at the boundary regulators along the Ibrahimia and Bahr Yusef canals. GDWD in Assiut prepares and maintains these H-Q curves.

GDWD in Assiut and GDIs in the governorates in the project area are the organizations directly involved in water distribution. On the other hand, CDT is responsible for the measurement and centralized monitoring of water levels at major regulators along the main canals, HAD, Lake Quarun, pump stations, main drain outlet, and some online discharge measurement facilities. The water level readings made by the CDT help check the water levels observed by GDWD, which are used to generate instructions on regulator gate operation.

Table 2-8.2 Challenges and countermeasures in the water management system

Item	Challenges	Countermeasures
Water level	The routine water distribution process is that the gate operator for the non-governing regulators reads the water levels observed by staff, then gauges and informs Water Distribution in Assiut by mobile phone. Therefore, it is not possible to rapidly evaluate and judge water distribution based on water level data because of the time gate operator takes to inform Water Distribution in Assiut by mobile phone of hand copied data.	The pressure-type water level sensor will be installed in each regulator to observe water levels in real time, and transmit the observed data to a water monitoring system at one site.
Instructions on water distribution	Water Distribution in Assiut does not decide on all water distribution in the project area. Only the regulators located on the border between districts is operated by Water Distribution. Therefore, it isn't possible to confirm the state of distributed water at one site because the regulators that are not on a border are operated at a local irrigation district level.	A new water distribution inspectorate will be established so that the instructions and judgment of equal water distribution will be evaluated by one organization.
Feedback for monitoring	The observed water level data is transmitted to the Water Distribution in Assiut three times a day. Therefore Water Distribution does not know the water level immediately after the operation of the gate, or whether the gate obeyed the instruction from Water Distribution.	For gathering a wide range of scattered water level data at one monitoring site, equipment must be installed to transmit, gather, record, visualize, evaluate, and store data at a central monitoring

	Water level data is transferred by voice through mobile phones and is then recorded by hand at Water Distribution. Therefore, it takes time to evaluate the distributed water situation and errors are likely when recording and transmitting data. In addition, evaluations cannot be made by visual charts and graphs.	house.

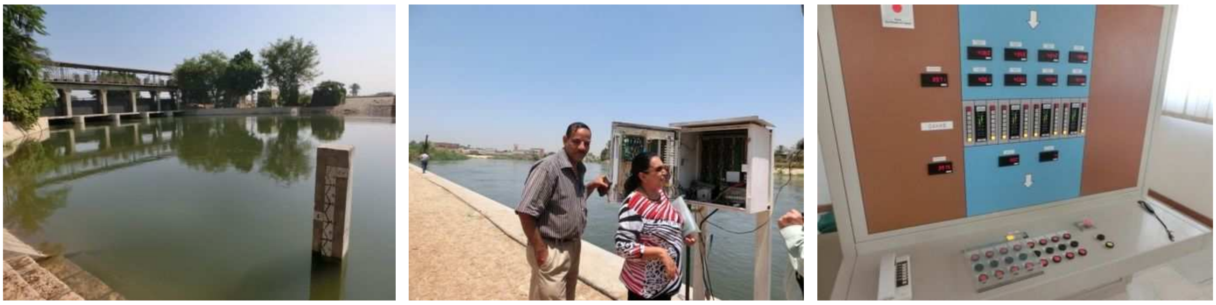
2-9 Current water management administration with the organization chart

The water management system consists of the above-mentioned three major organizations: 1) GDWD, 2) GDIs, and 3) gate operator (see Figure 2-8.1). Information on water level operation is centrally collected at GDWD in Assiut. However, because the operation of the intermediate regulators are managed by the GDIs of respective governorates, it is not possible for GDWD in Assiut or the GDIs of other governorates to verify whether the water levels in the main canals in the governorate concerned are being appropriately managed. Therefore, suspicions regarding water distribution may arise between GDWD in Assiut and the GDIs.

As mentioned above, the water level data monitored by the CDT is used as reference data to indicate water distribution instructions by GDWD in Assiut. Three different types of water level gauges shown in Figure 2-9.1, are used for monitoring of water levels at the regulators.

Because the water levels in canals are measured by the CDT in accordance with MWRI policy, the water level data obtained at these stations are utilized by GDWD as reference only. The water levels are also monitored at the gate control houses at regulators along Bahr Yusef canal. However, these water level data are not utilized to decide water distribution.

One of the issues of the water level monitoring equipment related to the regulators along the Bahar Yusef canal is the lack of maintenance of the water level sensor and the lack of instruction on the gate operation from GDWD and GDIs. Daily maintenance of the water level sensor is important from the viewpoint of sustainability utilization of these equipments. The responsible organization for the maintenance of these equipments is IIS. Figures 2-9.2 and 2-9.3 show the outline of the water level monitoring system introduced by the CDT.



Water Level gauging staff
(New Minia regulator)

Data transfer by telemetry
(Dahab regulator)

Dahab control house
(Dahab regulator)

Figure 2-9.1 Existing water level monitoring system
(left: a station at the Water Distribution, center: a station of the CDT, right: IIS)

Table 2-9.1 Issues and countermeasures in the design of the water management organization

Item	Design problem	Countermeasure
Ensuring that water level observation is monitored by each organization individually.	Water Distribution in Assiut is monitored on a marble water level meter indicating the same water level data monitored by CDT. However, GDWD's monitored data is recorded manually. And furthermore, the water level monitoring equipment is poorly maintained.	Integration of water level for monitoring and evaluating by a unified set of water level data.

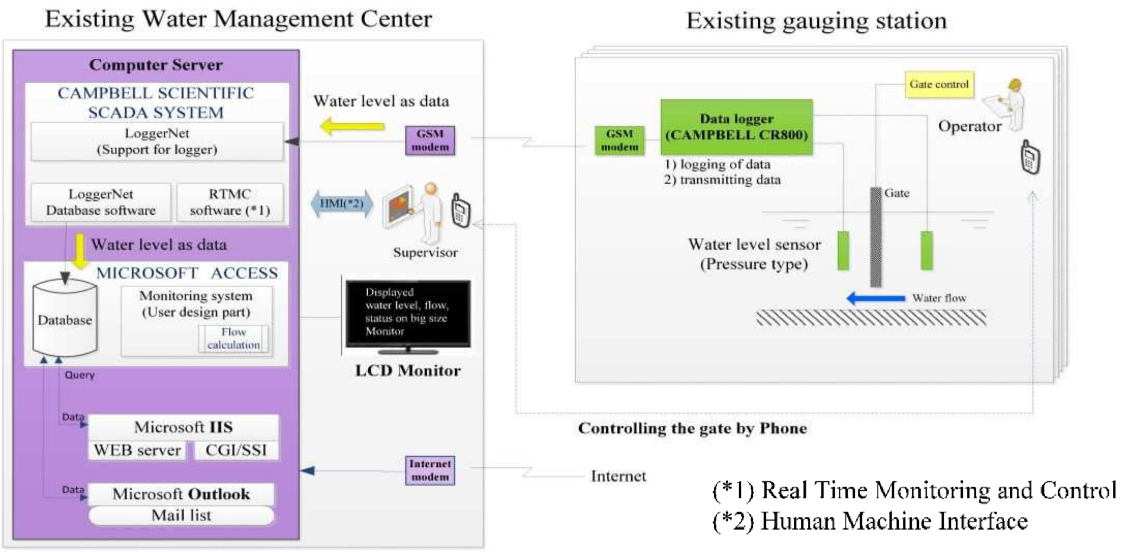

Existing Water Management Center
Computer Server
CAMPBELL SCIENTIFIC SCADA SYSTEM
LoggerNet (Support for logger)
LoggerNet Database software
RTMC software (*1)
Water level as data
MICROSOFT ACCESS
Database
Monitoring system (User design part)
Flow calculation
Query
Data
Microsoft IIS
WEB server
CGI/SSI
Data
Microsoft Outlook
Mail list
Water level as data
GSM modem
HMI(*2)
Supervisor
Displayed water level, flow, status on big size Monitor
LCD Monitor
Internet modem
Existing gauging station
GSM modem
Data logger (CAMPBELL CR800)
1) logging of data
2) transmitting data
Gate control
Operator
Gate
Water level sensor (Pressure type)
Water flow
Controlling the gate by Phone
Internet
(*1) Real Time Monitoring and Control
(*2) Human Machine Interface

Figure 2-9.2 Diagram of water management system of the CDT

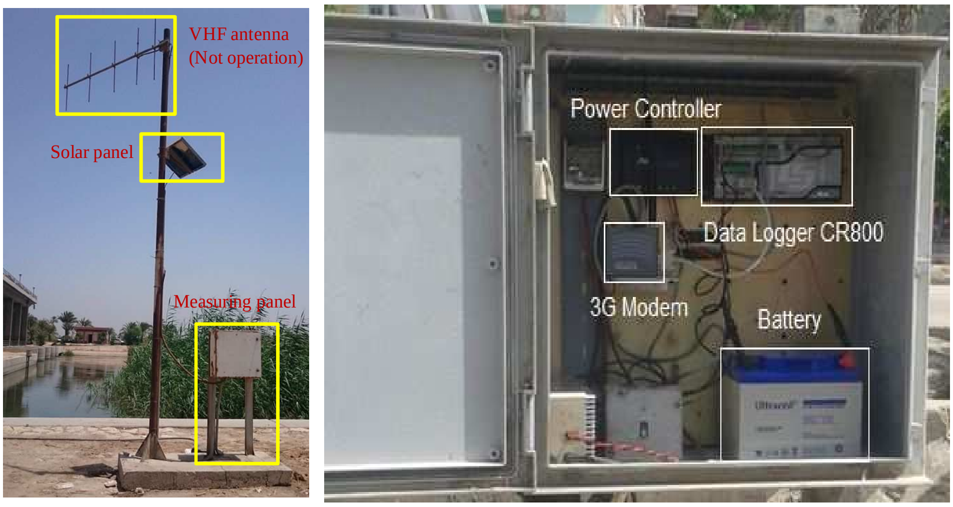


Figure2-9.3 Water level data transmission system developed by the CDT

3. Formulation of Integrated Water Management System

3-1 Setting up integrated water management system

(1) Effectiveness of the integrated water management system

Each facility in the irrigation system consists of water diversion facilities, regulators, main canals, intakes for branch canals, branch canals, farm land and drainage canals. In order to efficiently distribute water to 600,000ha-irrigation area in accordance with irrigation system requirements, each facility must fulfill its function satisfactorily. The scope of integrated water management system shall include not only the four regulators on the Bahr Yusef canal constructed through the grant aid from Japan, but also the irrigation facilities on the main canals under the supervision of the GDWD in Assiut of MWRI and that of GDIs. The irrigated area of the the main canal of the Project is a large area of 600,000 ha and the extension of the main canal is as long as 300 km. Therefore, it is indispensable to construct a system capable of unified monitoring of the water distribution status from the remote area. The following factors are considered as the necessity of introducing the water management system.

- Correction of the disparity in water distribution among the governorates
- Implementation of water distribution without surplus or shortage which is actually allocated based on the amount of water supplied data from the Ibrahimia head Regulator
- Efficient use of irrigation water by eliminating ineffective discharge
- Stabilization of water levels in the main canals
- Improvement of the transparency of the water distribution system
- Improvement of the safety of the system
- Utilization of collected data through upgrading of the management system

In view of the characteristics of each project area, the effect through the introduction of an integrated water management system is listed below.

- Rational water distribution

  The following items are expected; (1) the discharge in the main canals at the regulators, (2) the amounts of water distributed for irrigation between the regulators, (3) appropriate water distribution without surplus or shortage, and (4) equitable distribution of water in accordance with the agreement on water rights of each governorate in the area. The water allocation should be appropriately allocated by each weir based on the amount of water actually supplied from Ibrahimia. This leads to fair water management.

- Better understanding of the water distribution

  Using a system of centralized monitoring of water distribution and a visual display of water levels at multiple locations, enables anyone to confirm actual water distribution and the state of water distribution. An integrated water management system with a visual display function allows governorates with conflicting water usage interests to verify that the limited water supplied to the irrigation system is distributed equitably among them, hence the introduction of the system is expected to improve transparency of water distribution.

・Timely instructions on water distribution

This system allows for the centralized collection of monitoring data and the use of this data to guide instructions for water distribution to a wide area. This function of the system is expected to support the person in charge of water distribution in deciding on which water distribution instructions to issue

・Improvement of operation/maintenance of the irrigation facilities

As the system monitors water levels at the major irrigation facilities scattered over a wide area, abnormal water level data detected by the system show the identification of malfunction facilities and inappropriate water distribution. Therefore, this function is expected to enable timely and improved operation/maintenance of the irrigation facilities.

(2) Target facilities to be covered with integrated water management system

In order to distribute effectively the limited water resources in a large irrigation area, an integrated water management system that enables centralized management of irrigation facilities scattered across the region is necessary. The system to be introduced in the project area is for the monitoring of the irrigation facilities along the main canals, which are the mainstay of the economic activities in the area.

The target facility in water management covers the beginning facility of the main canal such as head regulator, the important facility for management along the main canal, and the branch canal intake with the large amount of water distribution from the main canal to the branch canal. In this area, targeted facilities are selected according to the following policies.

i) Regulators

Ibrahimia Head Regulator, New Dirout group of regulators, regulators on the Bahr Yusef canal and the Ibrahimia canal

ii) Intakes for major branch canals

The Technical Guidelines for the Water Management and Controlling Systems (Ministry of Agriculture, Forestry and Fisheries of Japan, 2013) indicate as a method of determining the target facilities for monitoring in a branch canal intake by using a distributed water amount grasping rate. In this method, in the case of the large and small branch canal intakes are irregularly scattered at locations, the range of the management target is selected based on the one with the larger amount of water distribution from the main canal to the branch canal. It is generally considered that the grasping rate of the targeted facilities is about 70 to 80% of the total amount of discharge. In this Project, the grasping rate of the monitoring facilities is set at 80%, and facilities that exceed 10,000 feddans are also monitored. Because the amount of distributed water into each branch canal is considered to be proportional to the size of the command area for each branch canal in the Project area, the branch canals to be monitored by the monitoring system are selected based on the size of the command areas.

In the F / S stage, the selection of the top 80% of the monitoring target was examined in the Bahr Yusef canal and Ibrahimia canal, respectively. However, in this D/D stage, facilities that are included in the grasping ratio of 80% of the beneficiary area of the Ibrahimia Head Regulator (1,565,100 fed) were selected as irrigation facilities to be monitored. Through this review, a branch canal intake with a larger command area will be added to the targeted monitoring facilities, which will contribute to grasping the water distribution status more widely.

In F/S, the top 80% of the branch canals in the irrigation areas of the Bahr Yusef and Ibrahimia canals were selected for monitoring. Meanwhile, in the D/D, the selection of the top 80% was made from the entire 1,565,100 feddans irrigated by the water diverted by the Ibrahimia Head regulator. This re-selection not only resulted in the inclusion of branch canals with larger beneficiary areas in the system, but was also expected to improve the monitoring of water distribution.

Table 3-1.1 Criteria for the selection of branch canals to be monitored

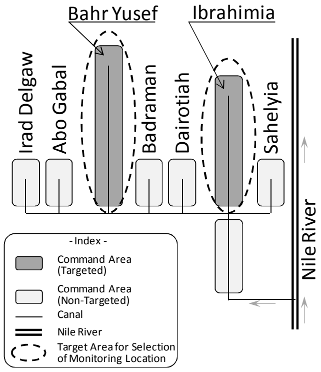
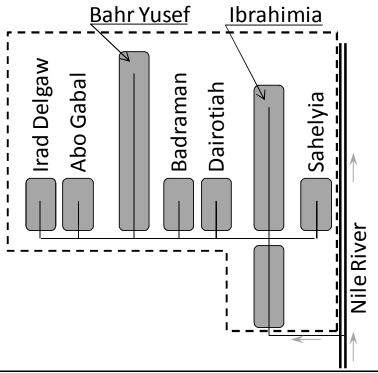
F/S	D/D
The range of the top 80% of the grasp rate was carried out for each of the Bahr Yusef canal (808,000 fed) and Ibrahimia canal (576,700 fed). - Grasp rate of more than 80% along the Bahr Yusef canal - Grasp rate of more than 80% on the Ibrahimia canal	The range of the top 80% of the grasp rate was carried out for all beneficiary area (1,565,100 fed). - Grasp rate of more than 80% for whole area
 Bahr Yusef Ibrahimia Irad Delgaw Abo Gabal Badraman Dairotiah Sahelyia Nile River - Index - Command Area (Targeted) Command Area (Non-Targeted) Canal Nile River Target Area for Selection of Monitoring Location	 Bahr Yusef Ibrahimia Irad Delgaw Abo Gabal Badraman Dairotiah Sahelyia Nile River

Table 3-1.1 shows the result of comparing the numbers at measuring points in F/S and D/D. At the time of reselecting the branch canals to be monitored, (1) the beneficiary area of the Bhbashen branch canal was revised from 23,000 feddans in F/S to 2,300 feddans in D/D, and (2) the beneficiary areas of the five small regulators in the DGRs was included in the beneficiary area used in the selected 80% of branch canals.

In addition to the size of irrigated areas selected, it is also necessary to evaluate the importance of irrigation facilities from the viewpoint of water management. In consultation with GDWD, the inclusion of an irrigation facility that was considered important to the water management of the facilities was selected for monitoring. Table 3-1.2 and Figure 3-1.1 show the facilities to be monitored. A comparison table showing the difference in the facilities selected for the monitoring in this survey and those in F/S are shown in the appendix.

Table 3-1.2 Facilities targeted for monitoring (1/2)

Irrigation facilities			Name of the Target facilities		No.
Regulator	Bahr Yusef canal		Dahab Regulator Sakoula Regulator Mazoura Regulator	Lahoun Regulator Abo El Shekok Regulator Regulator km39	6
	Ibrahimia canal		New Hafze Regulator Matay Regulator Maghagha Regulator	Sharahna Regulator El Gandy Regulator Ashmont Regulator	6
Branch canal	Bahr Yusef canal	Intake	Manshat EL Dahab El Hareka El Sabaa	Quftan Wesh El-Bab EL-Giza	6
		Weir	Hassan Wasef Weir		1
		Pump	New Kamdeer P.S. New Terfa P.S. Old Terfa P.S.	Old Sakoula P.S. Mazoura P.S.(2)	5
	Ibrahimia canal	Intake	Irad El Maharak El Kosia East Hafze West Hafze Adkak	Gendia Abo Shosha EL Soultany Tansa El Mansour	10
		Weir	Serry Weir	Maghagha Weir	2
Ibrahimia main canal			Ibrahimia Head Regulator		1
Lake			Quarun Lake		1
Total					38

Table 3-1.3 Facilities targeted for monitoring (2/2)

Irrigation facilities	Name of the Target facilities		No.
Dirout Group of Regulators	Bahr Yusef Regulator Ibrahimia Regulator Irad Delgaw Regulator Abo Gabal Regulator	Badraman Regulator Dairotiah Regulator Sahelyia Regulator	7
Total			7

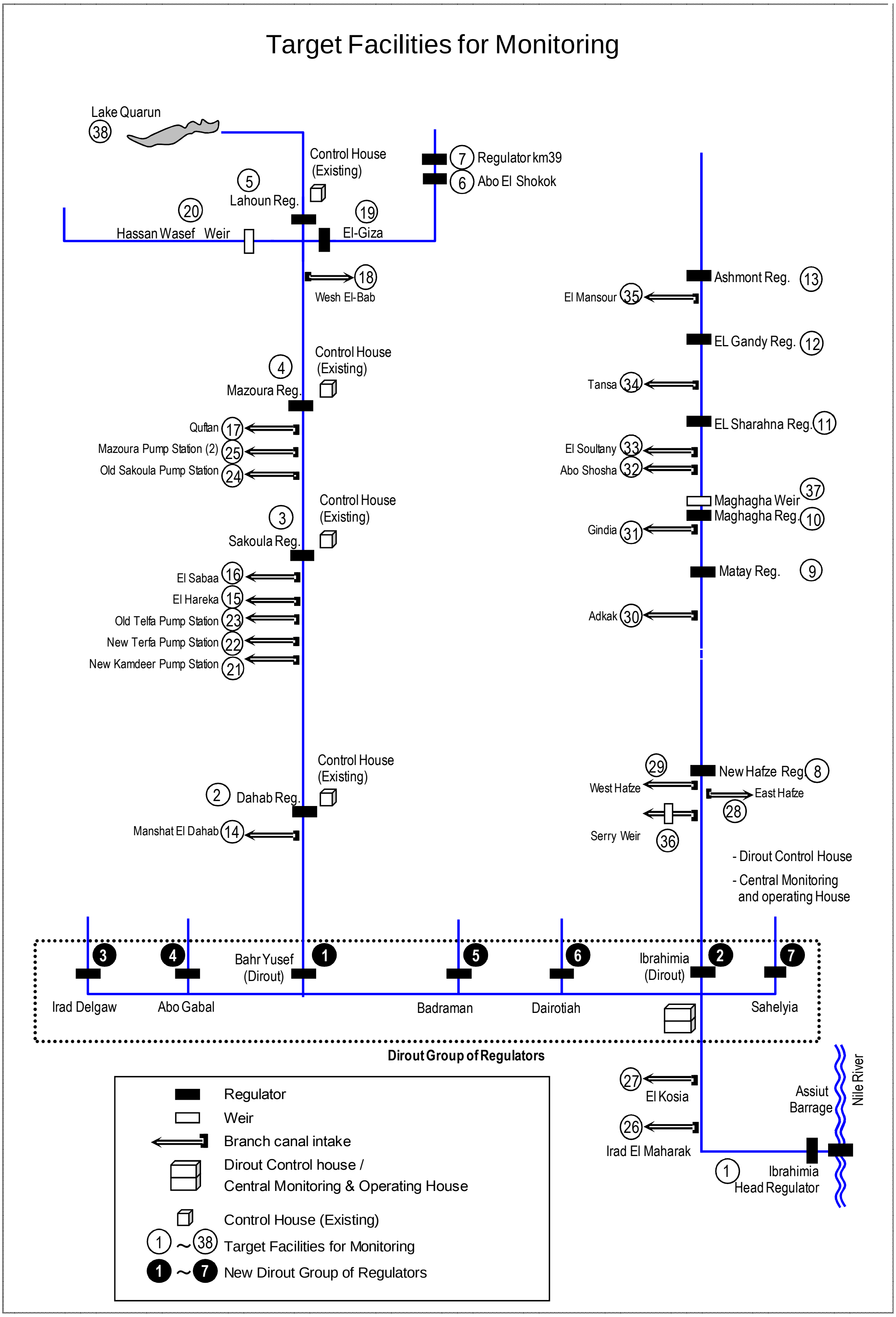


Figure 3-1.1 Schematic diagram of the facilities to be monitored in water management system

(3) Plan for the central monitoring and operating house

The development of the telemetry system has progressed significantly since F/S stagein 2010. The establishment of a central monitoring house in Beni Suef Governorate was recommended during F/S stage. The establishment of a central house in Minia Governorate and in Dirout was discussed during B/D stage. The realization of equitable water distribution requires the establishment of an “independent organization” that is not influenced by the requests of governorates for water distribution, and so there is a plan to establish a Central Monitoring and Operating House.

The D/D consultant recommends that the Central Monitoring and Operating House be responsible for unbiased distribution of water beyond governorate boundaries. And in the near future, the consultant also considers it important to develop the Central House into a highly sophisticated facility that, for example, performs water distribution based on forecasts of the size of irrigation areas and cropping patterns that are made using satellite imagery. MWRI can use this data to develop new farmlands and achieve the effective water distribution that their policies stipulate. For the development of such a facility, the consultant recommends the establishment of the Central House in an area where specialists in irrigation engineering, agriculture, and communication will be available.

In B/D, a plan to construct the Central Monitoring and Operating House in Dirout, adjacent to the NDGRs Control House or Irrigation District office was discussed within the framework of the activities of the water management working group. RGBS finally recommended and confirmed that Central Monitoring and Operating House will be constructed together with NDGRs control house in Dirout together with NDGRs control house.

(4) New categorization of monitoring and operating levels

Classifications pertaining to monitoring and controlling focus mainly on (1) what kind of information shall be measured, monitored, and operated at each irrigation facility and (2) how various collected information shall be classified, stored, and processed, and (3) how processed information shall be displayed, recorded, and controlled. The recommendation for categorizing monitoring level is described in Table 3-1.4 with the “Target facilities for integrated water management system” mentioned above.

As shown in Table 3-1.4, the gates of regulators in the project area shall not be controlled remotely from the Central Monitoring and Operating House. Only water levels shall be monitored remotely as planned in F/S stage, and the gates shall be operated onsite by a gate operator. The reason for not implementing the remote control is that, if the gate of a regulator is operated from a location 100-300kms from the regulator, opportunities for confirming the safety of the gate operation and the early detection of malfunction in the event of signs of abnormality during gate operation will be lost. Discussions in the water management working group concluded that telecontrol of the gates was not recommended from a safety perspective, or in the interest of promoting daily inspection and maintenance of the facilities.

Table 3-1.4 Study on the monitoring and operational level

				Current Situation		Current Function			Target of Supervisoriy Facilities		On-site	Control Room (Regulator along Bahr Yusef)						Central Monitoring House					
									Current State	Plan		Contorol			Supervisory			Control			Supervisory		
				Water Level Monitoring	Discharge Observation	Water Distribution between each District Level	Intake for Secondary Canal	Water level Adjustment along Main Canal	Appropriate Water Distribution along the Main Canal (Bahr Yusef Canal)	Appropriate Water Distribution for Main Canal and Major Secondary Canal	Manual Operation	Manual Operation	Manual Control with Preset Values	Automatic Control	Gate Status	Water Level	Discharge Observation	Manual Operation	Manual Control with Preset Values	Automatic Control	Gate Status	Water Level (US & DS)	Discharge Observation
Ibrahimia Head Regulator				○	○				○	○	○	○			○	○	○					○	○
Dirout Group of Regulators				○	○	○		○	○	○	○	○			○	○	○					○	○
Bahr Yusef Canal	Regulator	Dahab		○				○		○	○	○			○	○	○					○	○
		Sakoula		○	○	○		○	○	○	○	○			○	○	○					○	○
		Mazoura		○				○		○	○	○			○	○	○					○	○
		Lahoun	Lahouh	○	○	○		○	○	○	○	○			○	○	○					○	○
			Hassan Wasef	○	○					○	○	○			○	○	○					○	○
			El-Giza	○	○					○	○	○			○	○	○					○	○
	Branch Canal Intake	Intake(1)					○			○	○											○	
		Intake(2)					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		Intake(10)					○			○	○											○	
Ibrahimia Canal	Regulator	Hafze		○				○		○	○					○						○	
		New Minia		○				○		○	○												
		Matay		○				○		○	○											○	○
		Maghagha		○	○	○		○	○	○	○					○	○					○	○
		El Sharahna						○		○	○											○	○
		El Gandy						○		○	○											○	○
		Ashmont						○		○	○											○	○
		El Wasta		○	○	○		○	○	○	○					○	○						
	Branch Canal Intake	Intake(1)					○			○	○											○	
		Intake(2)					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		·					○			○	○											○	
		Intake(14)					○			○	○											○	
Quarun Lake				○					○	○						○						○	

Tables 3-1.5 and 3-1.6 show the monitoring and controlling levels of the Central Monitoring and Operating House and the regulators along the Bahr Yusef and Ibrahimia canals, respectively. In addition to its remote monitoring function, the Central Monitoring and Operating House shall be equipped with a calculation function that allows it to evaluate water balance by comparing the supply and demand for discharge. This calculation function is a tool intended to support the person in charge of decision-making regarding water distribution.

Table 3-1.5 Study on the management levels at regulators

	Monitoring				Recording			Operation/Control				Data Processing		
	Onsite Operation	Display Panel	Mini-Graphic Panel	CRT Display	Daily Log Recording	Analog Recorder	Recording (Printer)	Manual Operation from Operation room	Onsite Manual Operation	Manual Control with Preset Values	Automatic Control	Supervisory and Warning Processing	Calculation Processing	Forecasting Processing
B	○				○			○	○			○		
I	○				○				○			○		

B：Regulators along Bahr Yusef canal
I：Regulators along Ibrahimia canal

Table 3-1.6 Study on the management level at the central monitoring center

	Supervisory			Recording		Operation/Control			Data Processing		
	Display Panel	Mini-Graphic Panel	CRT Display	Analog Recorder	Recording (Printer)	Remote Control	Manual Control with Preset Values	Automatic Control	Supervisory and Warning Processing	Calculation Processing	Forecasting Processing
Central Monitoring and Operating House	○		○		○				○	○	

(5) New water management organization

The establishment of a new organization consisting of representatives from the governorates impacted by the project areas is recommended to ensure an appropriate integrated water management system after the construction of the new DGRs. Figure 3-1.2 shows the planned composition of this new organization. GDWD approved the establishment of this new organization in the consultation at the B/D stage.

Figure 3-1.3 shows a conceptual diagram of the new water management system.

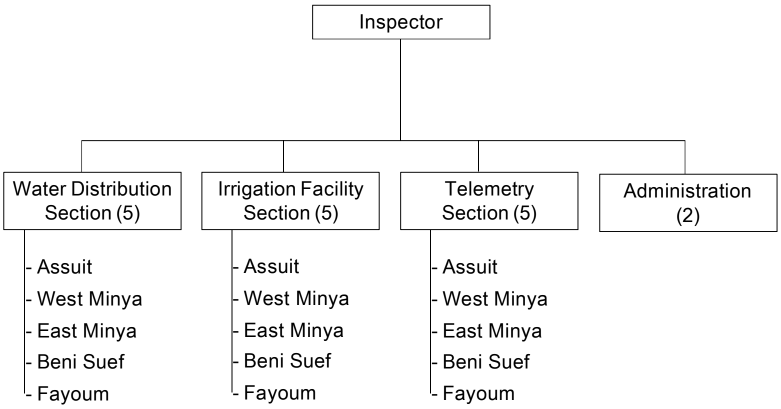


Figure 3-1.2 New organization for the integrated water management

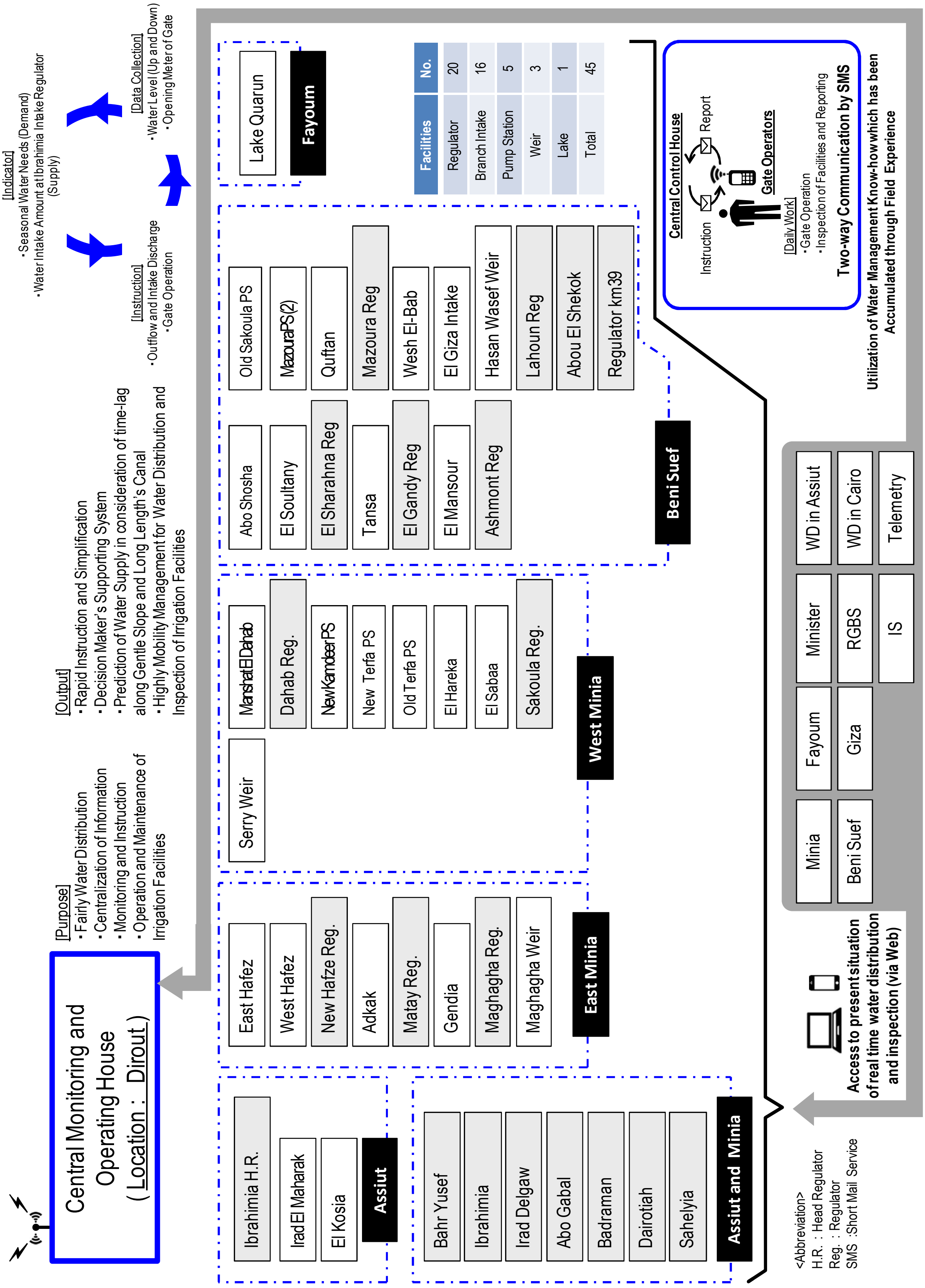


Figure 3-1.3 Hierarchic diagram for the integrated water management system

3-2 New centralized management system

As mentioned above, the water levels measured downstream of the regulators is the only data that GDWD in Assiut uses as an indicator of real-time water level for the gate operation of water distribution in the project area.

Remote monitoring of water level developed by the telemetry engineers and promoted by the CDT is expected to be utilized in the future following its wide dissemination because of its high expansibility and technical simplicity.

Therefore, the CDT-based monitoring system shall be used continuously for the remote monitoring of the water levels at the regulators in the main canals, at the intakes of the branch canals, and for data processing that converts water levels into flow rate.

In an interview at MWRI, it became clear that the CDT had developed a remote water level monitoring system to simplify the collection of water levels, pump status, meteorological data, and so on. MWRI is aware of the need for specialized technologies for the development of a system that can convert water level data into discharge, and determine the amount of water to be distributed to each irrigation canal by comparing the discharge and the water supply.

It was therefore decided that it was important to develop a system that assisted persons in charge of water distribution in the new organization, while continuing to make use of the monitoring system developed by the CDT. Figures 3-2.1 and 3-2.2 show the data flow in the integrated water management system proposed for the project concerned. The concept of water balance monitoring will continue to be discussed with CDWD.

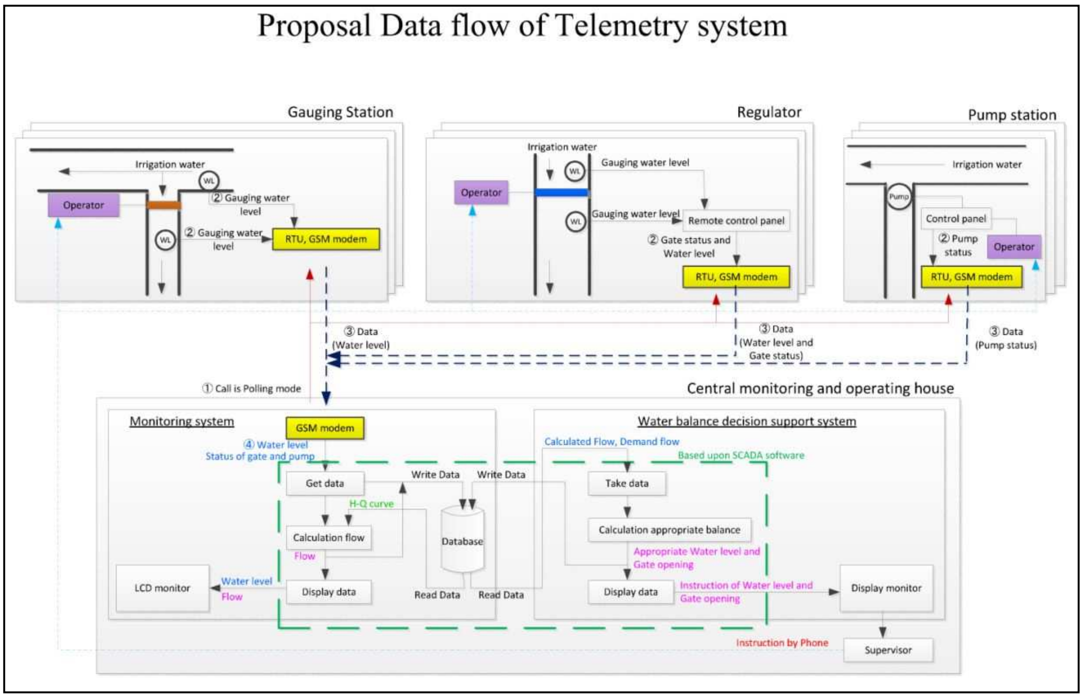


Figure 3-2.1 Data flow in the integrated water management system

The following steps show the data flow for measuring water level, and for collecting, transmitting, calculating, storing, and evaluating data. These steps are formulated based on the monitoring software which matches that of the existing telemetry system assembled by CDT.

1) Polling from the central monitoring house to the irrigation facilities to connect with central monitoring house and irrigation facilities such as regulators and branch canal intakes,
2) Gauging upstream and downstream water levels using pressure-type water level gauge at each irrigation facility,
3) Transmitting data from irrigation facilities to the central monitoring house via GPRS communication module,
4) Receiving water level data from irrigation facilities to the central monitoring house via GPRS communication module and storing the received data in the database server,
5) Calculating discharge at each regulator using H-Q curve which is saved on database server,
6) Storing the calculated discharge data onto database server,
7) Displaying water level data at each irrigation facility on an LCD monitor,
8) Reading the discharge data from upstream and downstream regulators, and requesting data from database server,
9) Comparing the difference in discharge between upstream and downstream regulators and requesting data from each regulator,
10) Calculating the appropriate amount of water for effective distribution and correct water level, and relaying gate operations from the central monitoring house to each gate operator onsite.

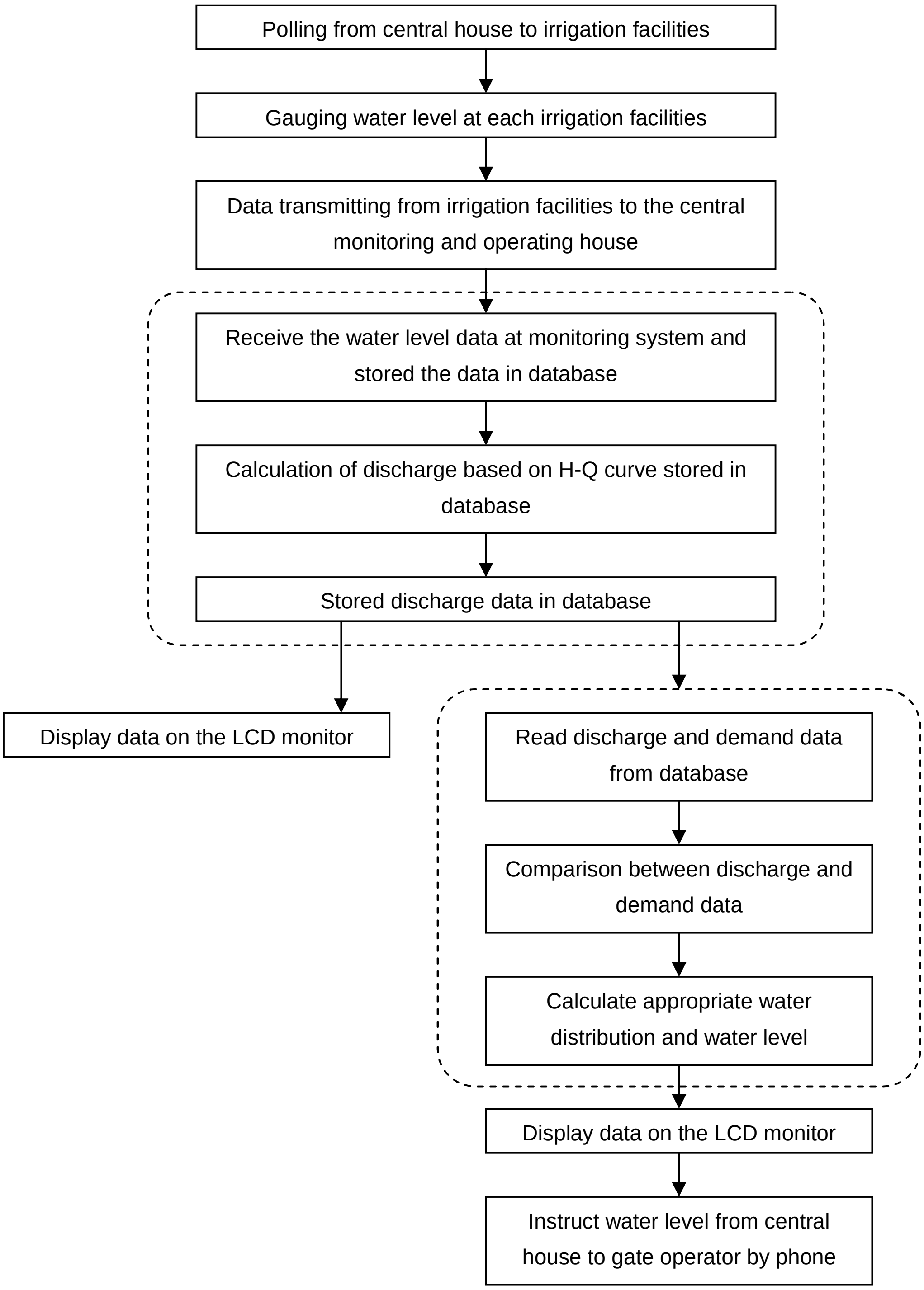

Polling from central house to irrigation facilities
Gauging water level at each irrigation facilities
Data transmitting from irrigation facilities to the central monitoring and operating house
Receive the water level data at monitoring system and stored the data in database
Calculation of discharge based on H-Q curve stored in database
Stored discharge data in database
Display data on the LCD monitor
Read discharge and demand data from database
Comparison between discharge and demand data
Calculate appropriate water distribution and water level
Display data on the LCD monitor
Instruct water level from central house to gate operator by phone

Figure 3-2.2 Data flow for the integrated water management system

4. Detailed Design

4-1 Design of transmission system and route

4-1-1 Date transmission network and protocol

In this chapter, the communication methods for water measurement in the integrated water management, data transmitting method, composition of gauging and monitoring stations and specification of equipments for each station are considered. The existing water management system is using the GPRS communication network system. And, the data transmission method is the TCP/IP method. The access point (APN (Access Point Name)), that is, the facility for implementing TCP/IP data transmission by GPRS communication, is managed by MWRI.

As described before, the integrated water management system uses the same communication method and data transmission method in order to integrate with the current telemetry system, and uses the same facility of APN.

GPRS communication has wide coverage area as a mobile phone network in Egypt. All the water level monitoring stations are located under this GPRS coverage area, which means securing communication coverage.

The TCP/IP method applying as a data transmission method is widely used in the internet and intranet networks. TCP/IP method has features of the detection of data transmission errors that is occurred when the communication network is unstable, and the function of retransmitting the data when an error occurred (securing data reliability).

The main function of the APN is to give an IP address to access the internet network. This IP address changes each time when the APN is requested to give an IP address. That is, it is very unlikely to communicate using the same IP address among each water level gauging stations. This makes it possible to avoid access from outside and attacks using IP addresses illegally (securing security).

Figure 4-1.1 and Figure 4-2.2 show the system composition using the GPRS communication method, and the system composition using the TCP/IP method respectively.

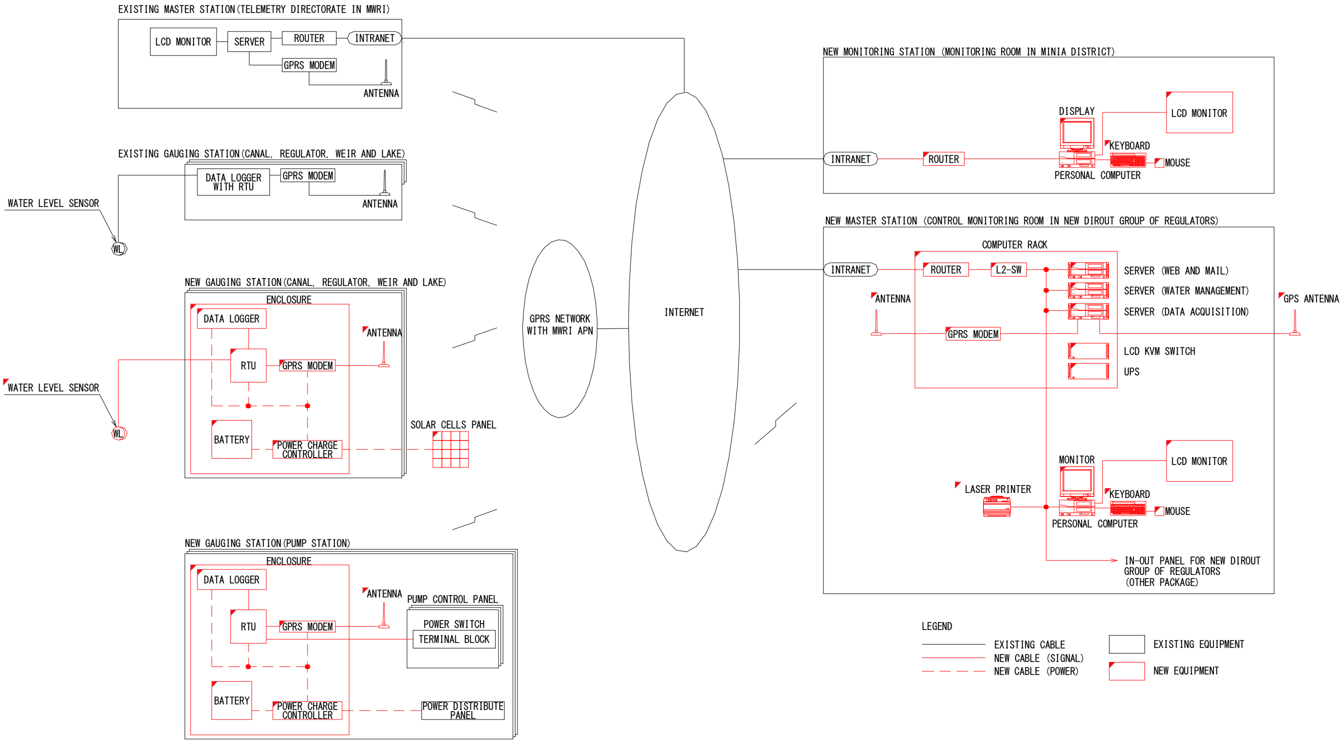


Figure 4-1.1 System composition of GPRS communication

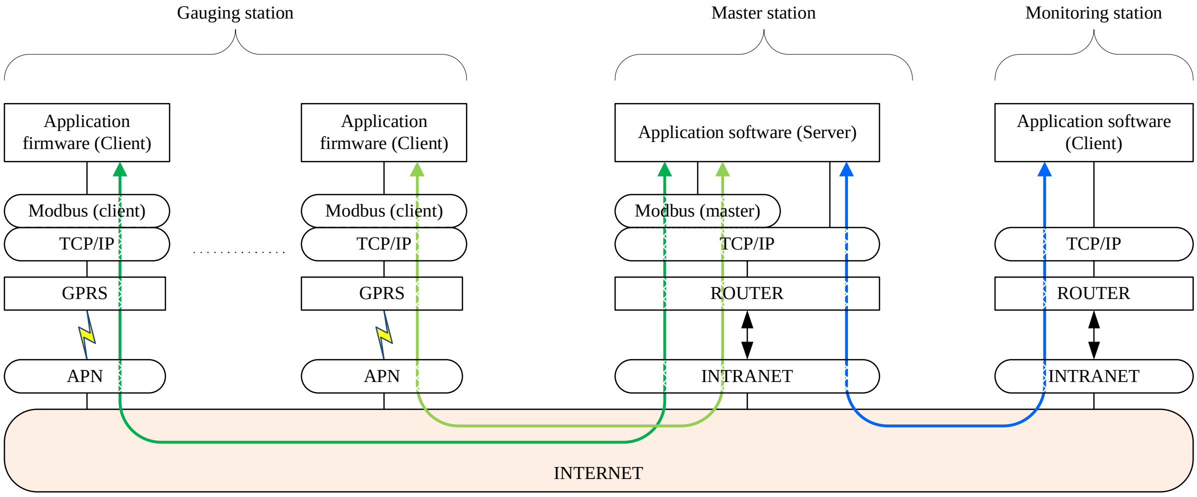


Figure 4-1.2 System composition using the TCP/IP method

4-1-2 Telemetry sub-system

Telemetry sub-system shall compose with Data acquisition server, RTU and relevant network equipment which are NTP server, GPRS modem, L2-SW and Router mainly. GPRS modem is connected to the GPRS network based upon IP (Internet Protocol) according to SIM card set up beforehand in this modem. The connection with this GPRS network is begun from RTU by the incoming connection.

The main incoming connection shall consist of the continuous connection and a regular time connection. Router shall be connected to the Internet through the ADSL provider or the broadband provider by the continuous connection. All the data from the gauging stations shall be gathered and processed at the master station. In Data acquisition server, the data is collected from 1024 RTUs or less.

The collected and processed of measurement data shall be stored in data base for ten (10) years and more, and shall be transferred to another computer system. This data will be collected by the data transmission function. All function to prevent unlawful access must be installed as a network security precaution.

4-1-3 Data transmission method

Telemetry sub-system corresponds to two data transmission methods of the autonomous transmission and call transmission.

(1) The autonomous transmission

The gauge station shall begin the data transmission autonomous when becoming set time. This transmission shall have the autonomous mode.

1) Autonomous mode

This transmission shall be started automatically by a clock of the gauging station. This clock will be implemented in RTU. And, this local clock is regularly corrected. A local clock synchronizes with the clock server of the master station, and this correction is completed. The protocol used by this clock synchronization will be NTP. Moreover, a local clock will be NTP client, and the clock server will be NTP server.

Data acquisition server of the master station shall always receive the data from all of the gauging station consecutively.

(2) The call transmission

In case of the call transmission, the data collection command will be activated from the master station mainly. The gauging station is called in a moment anytime when required. This transmission shall have the calling modes and the respond modes.

1) Calling modes

The system shall have the following four (4) kinds of calling mode.

Table 4-1.1 Calling modes

Calling modes	Description
Automatic calling	Automatic calling mode by a clock of Data acquisition server. There are seven intervals such as 15 minutes, 30 minutes, 1 hour, 3 hours, 6 hours, 12 hours and 24 hours.
Manual calling	This calling shall be started manually and be directed to the selected telemetry gauging stations by individual calling.
Manual calling to individual	This calling shall be started manually at any manually time, and shall be used for manual measurements, calling any of the stations manually selected.

Re-calling	The station called fails to respond or if any erroneous code has been detected in the data code received from the station called shall automatically recall the station once more. If there is still an erroneous code, or the station recalled fails to respond again, the system shall then shift to the next procedure, actuating visual and audible alarms to the operator.

a) Automatic calling

This calling shall be started automatically by a clock of Data acquisition server, and shall call each gauging stations consecutively. The calling shall be made at one of the following seven (7) intervals: fifteen (15) minutes, thirty (30) minutes, one (1) hour, three (3) hours, six (6) hours, twelve (12) hours and twenty-four (24) hours.

The automatic calling shall have priority over another calling: i.e. one (1) minutes before the scheduled calling, manual calling shall be automatically done until the end of the observation. The calling time intervals shall be able to be selected optionally, and the automatic calling shall have an operational priority under normal conditions over other modes of calling listed above. The priority control of the automatic calling system shall be able to be released in case of an emergency. The designated calling time interval is one (1) hour.

b) Manual calling

This calling shall be started manually and be directed to all the selected telemetry gauging stations by individual calling. And it shall be used for manual measurements, calling all stations one by one in the present order.

c) Manual calling to individual

This calling shall also be started manually at any manually time, and shall be used for manual measurements, calling any one of the stations manually selected.

d) Re-calling

The station called fails to respond or if any erroneous code has been detected in the data code received from the station called shall automatically recall the station once more. If there is still an erroneous code, or the station recalled fails to respond again, the system shall then shift to the next procedure, actuating visual and audible alarms to the operator.

Moreover, re-calling shall be actuated only for the individual gauging station after the completion of the automatic calling. The maximum time required for calling and response to one gauging station shall be less than 20 seconds.

e) Response modes

The gauging station called by the master station shall send the data which is composed with the measuring data, status and warning immediately.

4-1-4 Transmission format

(1) General

The basic transmission format shall be as shown below. The Contractor shall propose the data format of the data acquisition referring to following items

1) Flag sequence

Flag sequence shall comprise 8 bits. It shall indicate the start or end of a frame.

2) Address bit

Address shall be used to represent station No., system No., group No., and area code. Address shall comprise 24 bits.

3) Control field

Control field shall indicate the function of transmission code such as automatic calling or individual calling or response. This field shall comprise 16 bits.

4) Information field

Information field shall be used present measured data, measured time data, flag data, etc. This field shall comprise 98 bits x n.

5) Frame check sequence

Frame check sequence shall comprise 16 bits.

Table 4-1.2 Transmission format

System	Specification
Flag sequence	8 bits
Address bit	24 bits (Station No., System No., Group No., Area code)
Control field	16 bits
Information field	98 bits x n
Frame check sequence	16 bits

(2) Calling signal format

Calling signal format for calling shall consist of as follows:

Flag sequence, Address bit, Control field, Information field, Frame check sequence and Flag sequence.

(3) Response signal format

The frame and word configuration of the response signal shall consist of as follows:

Flag sequence, Address bit, Control field, Information field, Frame check sequence and Flag sequence.

4-1-5 Data acquisition function

Data acquisition function shall be installed in the master station. Data acquisition function consists of the Server (Data acquisition), GPRS modem and Network function. Main function is shown below,

- Data transmission function

- ➢ Time control function
- ➢ Operation and status indication function
- ➢ Simplification database function

Data acquisition function shall collect all the information which is measurement data from the gauging station by call with data transmission function. Call is carried out through GPRS modem by the data acquisition function. This calling interval shall be set in the operation and maintenance screen of the data acquisition function. Data collected are stored in data base.

Table 4-1.3 Data acquisition function

No	Function	Contests
1	Data transmission	seven (7) intervals: fifteen (15) minutes, thirty (30) minutes, one (1) hour, three (3) hours, six (6) hours, twelve (12) hours and twenty-four (24) hours.
2	Time control and calibration	RTU, Data acquisition server and another server shall be connected to NTP server for calibrating a clock time by itself.
3	Time schedule management	Data acquisition server as a time management shall manage the transmission time of each gauging station
4	Registration and deletion	Registration and the deletion of the gauging station shall be done with the data acquisition server.
5	System monitoring	Data acquisition server shall supervise the status and condition of the communication
6	Data transfer	Data from the gauging station is transmitted by LAN interface from Data acquisition server to an outside database server
7	Screen display	The gauging data collected from the gauging station shall be displayed
8	Operation and status indication	Data acquisition server shall have functions for system monitoring and maintenance of gauging station on it display contents.
9	Simplification database	Data acquisition server shall include simplification database to store the received data such as present water level, status of equipment in the gauging station for temporary.
10	Other	The measuring capacity shall be expandable to a maximum 1024 gauging stations

(1) Data transmission function

As the call transmission, the automatic calling for data transmission function shall be conducted at seven (7) intervals: fifteen (15) minutes, thirty (30) minutes, one (1) hour, three (3) hours, six (6) hours, twelve (12) hours and twenty-four (24) hours. And, the manual calling shall be started manually and be directed to all the selected gauging station by individual calling.

As the autonomous transmission, data acquisition function shall always receive the data from all of the gauging station consecutively.

If any error code has been detected in the data from the gauging station, or if there is no response from the gauging station, that gauging station shall be automatically re-called once more. If there is an error code or a called the gauging station failed to respond again, a visible and audible alarm shall be actuated and the relative system shall shift to the next operation. The maximum time required for calling and response to one (1) gauging station shall be less than 20 seconds. This function shall have the following functions also:

- ➢ Selection of gauging stations
- ➢ Selection of calling time interval
- ➢ Selection of calling mode, automatic or manual calling

(2) Time control function and calibration function

RTU, Data acquisition server and another server shall be connected to NTP server for calibrating a clock time by itself. A clock time can be regularly corrected by NTP protocol. A clock time synchronizes with NTP server in the master station, and will be highly accurate. Therefore, NTP client shall be installed in RTU, Data acquisition server and another server for calibrating a clock time.

NTP server shall be connected GPS antenna, and shall provide year, month, day, hour and minute data. The time and date of NTP server shall be calibrated automatically, and the number of days on month shall be maintained automatically by an internal calendar program. The accuracy of a clock time shall be within one (1) seconds per day.

(3) Time schedule management function

Data acquisition server as a time management shall manage the transmission time of each gauging station, and the interval time between the gauging stations, and the switching time of the communication line, and the transmission schedule. The communication line switch time is required time to the communication line switch from the router route to the GPRS route.

The above-mentioned time management is registered in the time schedule management function.

(4) Registration and the deletion function

Registration and the deletion of the gauging station shall be done with the data acquisition server. Moreover, the observation stop setting of the gauging station is also possible.

(5) System monitoring function

Data acquisition server shall supervise the status and condition of the communication between the gauging station and the master station, and of the transmission between servers, and the gauging station. When abnormally generated, generation time and an abnormal content, etc. are accumulated as a history for thirty (30) days or more.

(6) Data transfer function

Data from the gauging station is transmitted by LAN interface from Data acquisition server to an outside database server which means the external server. Data acquisition server shall include simplification database to store the received data such as present water level, status of equipment in the gauging station for temporary.

The data received from all Gauging station shall store for 30 days in the simplification database. Data acquisition server shall have the function of reading data collected and processed by database through the LAN network.

(7) Screen display function

Data acquisition server shall have Screen display function. The gauging data collected from the gauging station shall be displayed the following items on the screen.

1) Present data and status

The current state of the collected gauging data is displayed. The visible alarm and sound are generated in this function when it receives information that the warning and the event information is detected.

2) Time schedule management

A time management which is composed with the transmission time of each gauging station and the interval time between the gauging stations and the switching time of the communication line and the transmission schedule is displayed.

3) Registration and the deletion

Registration and the deletion of the gauging station is for configured on display. Moreover, the observation stop setting of the gauging station is also for configured on display.

4) System monitoring

The status and condition of the communication between the gauging station and the master station and of the transmission between servers, and the gauging station is displayed. A history of the generation time and an abnormal content is displayed.

(8) Operation and status indication function

Data acquisition server shall have functions for system monitoring and maintenance of gauging station on it display contents. This server shall have, but not limited to, the following functions:

1) Operation

- Manual measurement
- Measurement interval change
- Missing data supplementation
- CSV save (for back up)
- CSV load (for loading from gauging station external media)
- Data correction
- Operation reset
- Alarm off

2) Monitoring

- Latest condition
- Received data

(9) Simplification database

Data acquisition server shall include simplification database to store the received data such as present water level, status of equipment in the gauging station for temporary. The data received from all Gauging station shall store for 30 days. Data acquisition server shall have the function of reading data collected and processed by database through the LAN network.

(10) Other

The measuring capacity shall be expandable to a maximum 1024 gauging stations, when required with minor modifications.

4-1-6 Computer Sub-system

Computer sub-system shall be composed of Water management function, Database function, Web & Mail function and Monitoring function. Computer sub-system shall be installed in the master station and the monitoring station. The monitoring station shall have Monitoring function only.

Computer sub-system shall have high quality graphics which shall be mounted within the “WINDOW” environment in order to be more accessible to the common user.

To spread an information and communication, the router shall be provided in the master station, and government authorities are connected each other using internet communication. When available capacity of Database and DAS will be less than the configured threshold, the alarm is displayed.

All function to prevent unlawful access must be installed.

(1) Water management function

Water management function consists of Server (Water management) and Network function.

When the data in Database is updated, the Flow and discharge are calculated on the water management function. And then, the water management function records the quantity of flow and discharge in Database. Main function is shown below,

- Database
- Flow and discharge calculation
- Operation and maintenance screen

1) Database

Water management function shall transfer the storage data from the Simplification database to Database by synchronization. And, Database shall provide the demand data to Web & Mail function.

Database software is preferably SQL or equivalent, which shall be possible to convert to usual database format such as Excel or Access or CSV file. The collected data and processed data in database shall be converted to any file format and shall be storage to CD/DVD or equivalent.

Water management server shall have the function of reading data collected and processed by data base through the LAN network.

2) Flow and discharge calculation

Water management function calculates the Flow and discharge in Database.

3) Operation and maintenance screen

Operational screen in the table form and the graph is made by using the data operated with data base, and disseminates it to external LCD monitor.

Operation and maintenance screen shall be composed with the information of water management which includes the name of gauging station, the item of measurement, the measurement data, time, and date, status of equipment, reporting and printing.

(2) Web & Mail function

Web & Mail function consists of Server and Network function.

Web & Mail function shall provide the web page including that information to give an accurate situation. The related government only can access this server by using browser. This access must demand ID and Password. And, between this server and web browser in clients the strong security device must be installed such as a firewall and router.

Web & Mail server shall have the function of reading data collected and processed by data base through the LAN network. Web file in the table form and the graph is made by using the data operated with data base, and disseminates the web file to LCD monitor, monitoring terminal by the function of the web opening to the public.

Mail with Report which is made in the water management server is sent by Mail function. The sender method used by the mail function shall be selected from E-mail and / or a short message (SMS). The report of water management will be transmitted to the registered addressee. The transmission cycle can be arbitrarily set.

(3) Monitoring function

Monitoring function consists of Personal Computer LCD monitor and Network function. Monitoring function shall be used to control and connect to the web server for monitoring measured data and processing data. Monitoring function shall have function to update display data automatically using Java language or equivalent and shall be installed at the master station and the monitoring station.

LCD monitor shall display the screen from the monitoring terminal. Laser printer shall print out the all necessary documents required from the LAN network.

(4) Network function

Network function consists of Router, L2-SW, LAN cable, Laser printer and Intranet. Network function shall be suitable to Ethernet and protocol shall be based on TCP/IP.

L2-SW shall be the hub where the switching facility is added. The switching hub shall learn the physical address (MAC address) of the Ethernet device connected to each port, and link port required for intelligence directly and enable it exchange data.

Router shall be the router equipped with the connection function conformed to existing intranet which is able to use internet line. Moreover, router, server and terminal shall have the function of security which means Malware inspection and Anti-virus. The computer virus and related malware must be completely excluded from the network and the relating equipment.

4-2 Design of gauging station

4-2-1 Location and function of gauging station

(1) Location of gauging stations

Gauging stations under the master station are shown on Table 4-2.1. The table shows the latitude and longitude coordinates of each gauging station, the provisional installation position of the water level sensor (the distance from the gate to the sensor), and the depth of the canal.

Table 4-2.1 Location of gauging stations

No.	Irrigation facilities			Name	Coordinate		Position of water level sensor (m)		
					Latitude	Longitude	Upstream (Distance before gate)	Downstream (Distance after gate)	Deapth of Canal
1	Ibrahimia Main Canal			Ibrahimia Head Regulator	27° 11' 44 .7"	31° 11' 07.8"	47	40	10
2	Regulator	Bahr Yusef Canal		Dahab Regulator	27° 59' 45.5"	30° 41' 25.84"	6	93	8
3				Sakoula Regulator	28° 39' 22.8"	30° 41' 15.7"	10	88	8
4				Mazoura Regulator	28° 53' 48.2"	30° 48' 43.8"	10	85	8
5				Lahoun Regulator	29° 12' 22.0"	30° 58' 15.7"	14	36	8
6				Abo El Shekok Regulator	29° 19' 34.86"	31° 07' 52.16"	15	27	8
7				km39 Regulator	29° 27' 23.7"	31° 11' 52.52"	9	20	8
8		Ibrahimia Canal		New Hafze Regulator	27° 48' 49.02"	30° 42' 15.5"	8	32	5
9				Matay Regulator	28° 24' 56.1"	30° 47' 15.1"	16	40	5
10				Maghagha Regulator	28° 38' 54.9"	30° 50' 14.3"	15	32	5
11				Sharahna Regulator	28° 51' 07.88"	30° 54' 48.29"	6	17	4
12				El Gandy Regulator	29° 05' 36.00"	31° 06' 29.03"	8	24	4
13				Ashmont Regulator	29° 11' 25.2"	31° 09' 49.9"	3	15	4
14	Branch Canal	Bahr Yusef Canal	Intake	Manshat El Dahab	27° 59' 52"	30° 41' 12.5"	2	25	3
15				El Hareka	28° 34' 54.32"	30° 40' 40.7"	2	20	3
16				El Sabaa	28° 34' 53.9"	30° 40' 39.2"	4	16	3
17				Quftan	28° 53' 41.4"	30° 48' 14.74"	6	20	3
18				Wesh El Bab	29° 03' 07.07"	30° 54' 50.81"	5	6	3
19				El-Giza	29° 12' 22.00"	30° 58' 15.7"	30	30	4
20			Weir	Hassan Wasef Weir	29° 12' 26.31"	30° 57' 42.11"	3m before weir	-	4
21		Ibrahimia Canal	Intake	Irad El Maharak	27° 22' 25.7"	30° 54' 14.1"	2	18	4
22				El Kosia	27° 26' 56.5"	30° 49' 33.0"	3	18	3
23				East Hafze	27° 48' 29.9"	30° 48' 26.7"	85	13	3
24				West Hafze	27° 48' 28.7"	30° 48' 23.3"	10	15	4
25				Adkak	28° 23' 20.7"	30° 46' 09.7"	3	55	4
26				Gendia	28° 38' 07.1"	30° 49' 39.13"	2	12	4
27				Abo shosha	28° 49' 54.14"	30° 54' 23.09"	3	30	4
28				El Soultany	28° 51' 05.37"	30° 54' 46.45"	3	16	4
29				Tansa	29° 00' 34.56"	31° 01' 14.01"	7	18	4
30				El Mansour	29° 11' 22.2"	31° 09' 48.5"	3	30	3
31			Weir	Serry Weir	27° 49' 17.2"	30° 47' 37.2"	10m before weir	-	4
32				Maghagha Weir	28° 39' 30.2"	30° 50' 45.1"	2m before weir	-	4
33	Pump Station	Bahr Yusef Canal		New Kamdeer PS	28° 9' 25.41"	30°39' 53.91"	25	60	$5^{*)}$
34				New Terfa PS	28°21'23.32"	30°37'40.31"	25	65	$5^{*)}$
35				Old Terfa PS	28°21'22.01"	30°37'39.99"	25	65	$5^{*)}$
36				Old Sakoura PS	28°37'13.43"	30°40'43.50"	25	40	$5^{*)}$
37				Mazoura PS	28°50'57.71"	30°48'2.64"	35	40	$5^{*)}$
38	Lake			Quarun Lake	29° 28' 1.08"	30° 42' 6.69"	observation well	-	2

NOTE; New Dirout Group of Regulators : Other package

**) Assumed value*

(2) Function of gauging station

Functions of gauging stations are shown in Table 4-2.2.

Table 4-2.2 Function of gauging station

No.	Function	Specification	Remarks
1	Measuring water level	The pulse of the water level is detected continuously and a proper water level can be obtained.	
2	Measuring discharge flow	The existing On/Off state of the power switch at Pump control panel is detected, and a proper discharge flow can be calculated in the server of the master station.	
3	Communication	The communication transmission line by GPRS is established between the gauging station and master station.	
4	Transmission	The water level, the state of the battery, and the state of the device are transmitted to the master station.	
5	Solar power	All devices work by the photovoltaic generation.	
6	Power saving	Power consumption excluding active works of the water level measurement and the data transmission becomes minimum.	

4-2-2 Function of gauging station at branch canal intake

(1) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at branch canal intake.

For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of upstream and downstream water levels in the main canal at the regulator are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The measurements of upstream and downstream water levels at the head of branch canal’s intake are monitored.

(3) Operation / Control

1) Branch canal’s gate : On-site control, No tele-control from remote site

(4) System diagram

Equipment composition and function composition are shown in Figure 4-2.1.

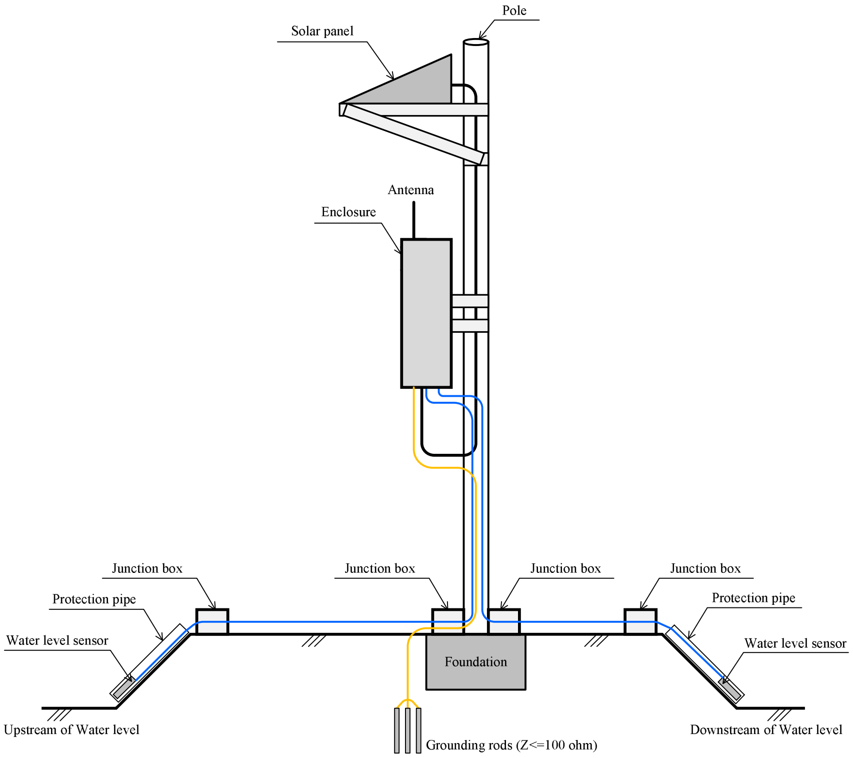


Figure 4-2.1 Equipment composition for gauging station (1/2)

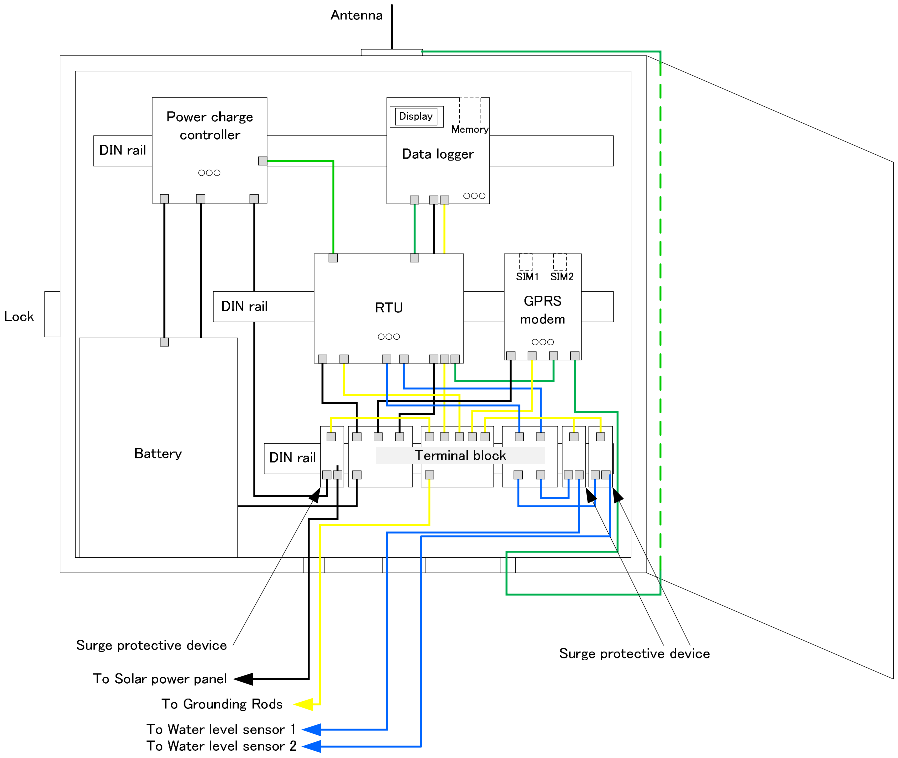


Figure 4-2.2 Equipment composition for gauging station (2/2)

Almost of all equipment shall operate in DC 12V (or 24V) which is fed from Storage battery. Power charge controller makes the electric power from the solar panel a fixed voltage, and charges the battery.

The water level sensor shall be measured in the input interface of RTU. The water level measured shall be recorded as measurement data in the data logger. The water level shall be recorded according to the setting of interval time in the data logger. And, all data can be monitored in the data logger.

The discharge flow shall be measured in the digital input interface of RTU. This interface shall connect to the existing spare points as a power switch interface on the terminal block in the Pump control panel. The discharge flow is calculated by the cycle of state (On / off) on the power switch. The existing power switch interface on the terminal block in the Pump control panel as the dedicated interface shall be prepared by MED before the connecting of this system.

Usually GPRS modem shall begin operating after it is called from the master station. GPRS modem called transmits the water level which is measured in input interface of RTU and also transmits the status of equipment at the same time.

Almost equipment shall be set up in an appropriate enclosure. And, the enclosure shall be mounted on the desk table or pole.

These functions to prevent unlawful access must be installed. And, function to prevent vandalizing also must be installed. Main function of gauging station is shown below table (Table 4-2.3).

Table 4-2.3 List of equipment composed in the gauging station

No.	Equipment	Quantity	Remarks
1	GPRS modem	1	
2	RTU with Data logger	1	
3	Charge controller	1	
4	Battery	1	
5	Solar panel	1	
6	Water level sensor	2	
7	Enclosure	2	
8	Pole	1	
9	Foundation	1	
10	Junction box	1	
11	Protection pipe	1	
12	Frame of solar panel	1	
13	Frame of enclosure	1	
14	Wiring cable	−	

4-2-3 Regulator

(1) Monitoring function

For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of upstream and downstream water levels at the head of branch canal’s intake are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The upstream and downstream water levels at the regulator are measured. The telemetry system installed through this project will be the compatible system with the one which have been installed nation-widely and maintained by Egyptian government. Therefore, the system to be introduced in the project shall be technically maintained and managed by the CDT itself

The water level monitoring equipment installed by the Japanese Grant Aid Project at regulators such as Lahoun, Mazoura, Sakoula, and Dahab is using as a Regulator’s gate operation index. Therefore, it is not easy for the CDT to maintain and manage said system systematically. Based on the above points, the introducing type of gauging station through this project will follow the same design concept that CDT has a lot of installation experience. In addition, gauging station will be newly installed on the upper and lower sides of each regulator, and monitoring from a master station remotely will be carried out.

(3) Operation / control

1) Regulator’s gate : On-site control, No tele-control from remote site

(4) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

4-2-4 Weir

(1) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at weir. For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of upstream water level in the canal at the weir are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The measurements of upstream water level in the canal at the weir are measured.

(3) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

4-2-5 Pump station

(2) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at pump station. However, since the power supply for the gauging station will be connected to the distribution power board of the pump station, it is about the power supply status of the pump station such as black out that will be monitored by the master station.

(3) Measuring function

The measurements of upstream (suction tank) and downstream (discharge tank) water levels in the canal at the pump station are monitored. Also, the operation status (On/Off) of each pump is measured, and the operation time is calculated and recorded based on the operation cycle. This data will be used to understand the amount of distributed discharge, and manage the pump station’s operations in the future.

1) Water level data

The measurements of upstream (suction tank) and downstream (discharge tank) water levels in the canal at the pump station are monitored.

2) Pump station’s status

The pumping station where the gauging station is installed is operated and managed by the MED. In this project, the modification work on the pumping station is out of scope. Therefore, the measuring equipment that recognizes the pump operation status (On/Off) and the output connection terminal on the control panel for each pump shall be modified by MED. The pumped discharge is calculated as the theoretical discharge amount by multiplying the pump operation time by the designed pumping ability of each pump.

(4) Operation / control

1) Pump station : On-site control, No tele-control from remote site

(5) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

Lake

(1) Monitoring function

The central monitoring house will monitors the status of the power supply system of the gauging station at Quarun Lake. For the commercial power supply, it is possible to know the status of the gauging station by the information of black out. However, since the power supply system of the gauging station consists of a solar panel and a battery, it is necessary to monitor the power status from master station.

1) Power supply status

Power supply status which is consisted of solar panel and battery will be monitored.

(2) Measuring function

The measurements of water level in the monitoring well of Quarun Lake are monitored. The data will be used to understand the amount of distributed discharge to manage the regulators at the main canal in the near future.

1) Water level data

The measurements of water level in the monitoring well are measured.

(3) System diagram

Description of equipment composition and function composition is omitted because the system is the same as that of the branch canal.

4-3 Wiring plan

Wiring plan of Regulators and Branch canal intake, and wiring plan of central monitoring house are shown in Figure 4-3.1 and Figure 4-3.2 respectively.

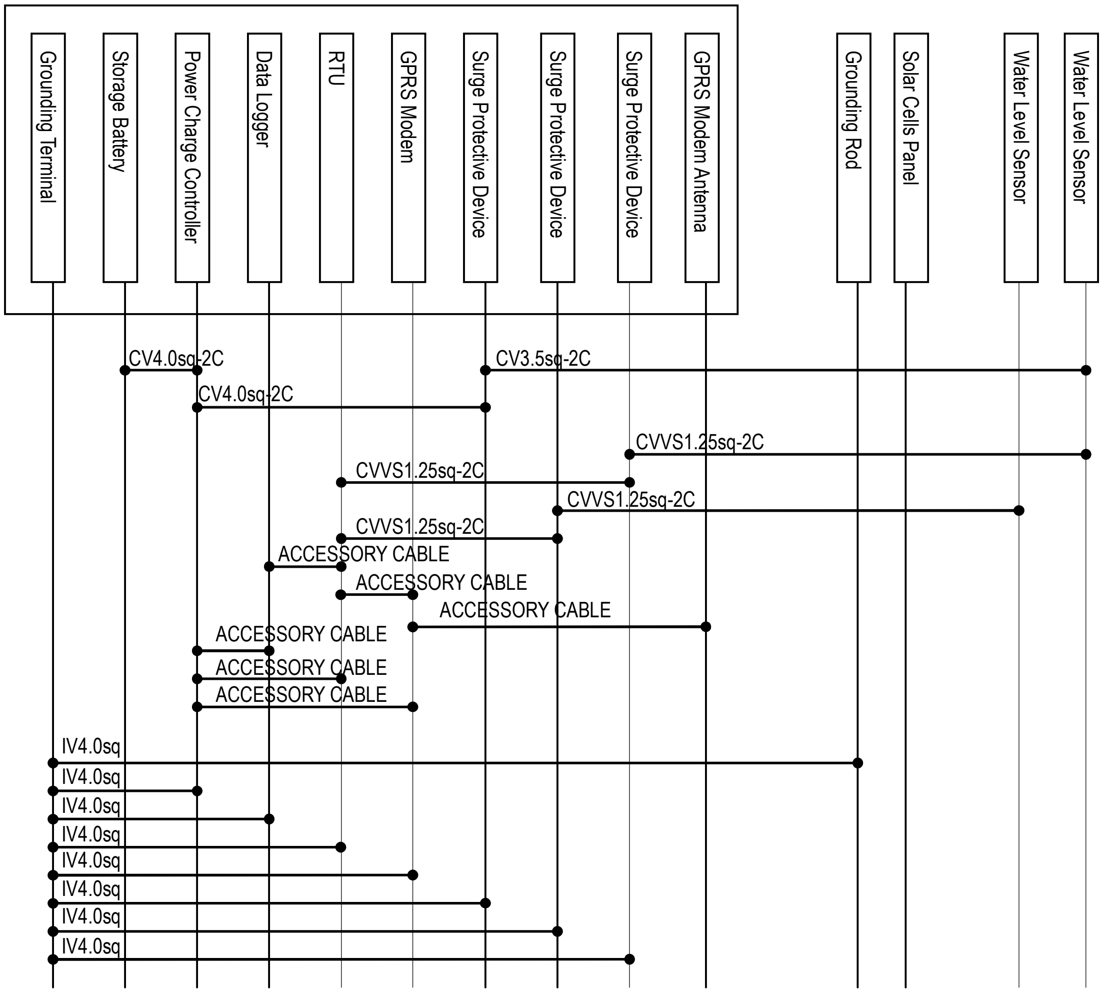


Figure 4-3.1 Wiring plan of regulator and branch canal’s intake

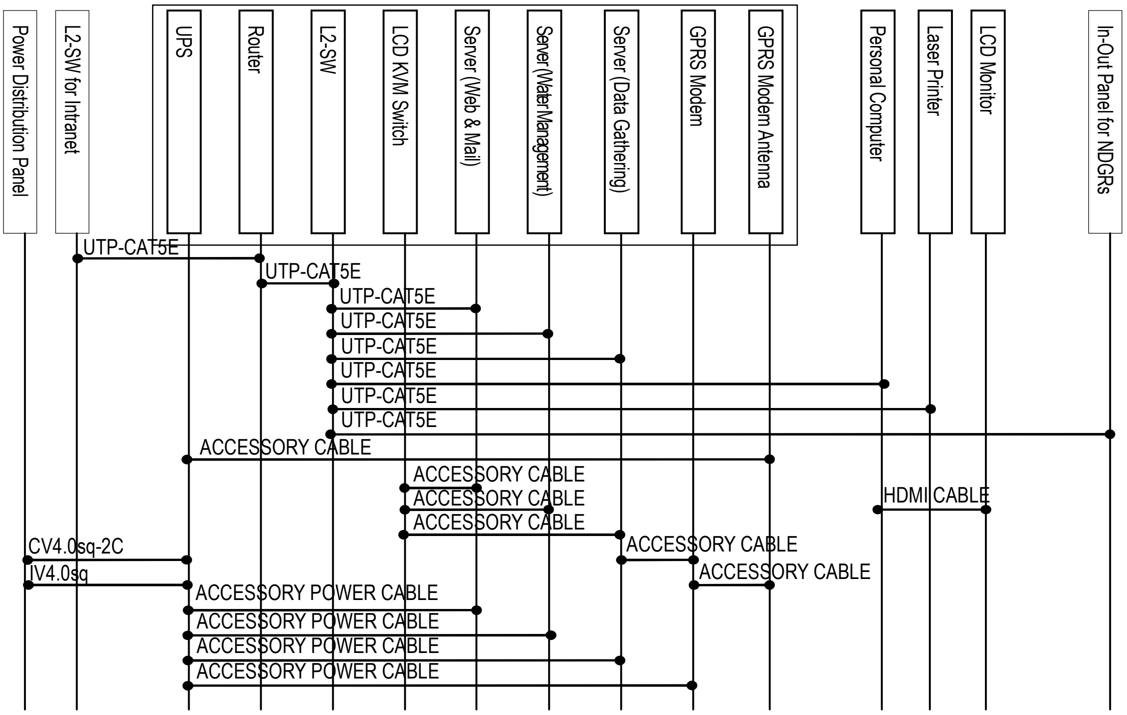


Figure 4-3.2 Wiring plan of Central Monitoring House

4-4 Gauging station plan

Construction of the gauging station in this area follows the existing telemetry station method. Each gauging station is mainly consists of enclosure, poles and fences.

The gauging station is planned to install along the road side except the location of Regulators. Therefore, in order to prevent theft or mischief at the gauging station, each device is fixed in an enclosure and surrounded by a fence. Devices such as GPRS modem, RTU, data logger, power controller, battery, surge protector are stored in the enclosure.

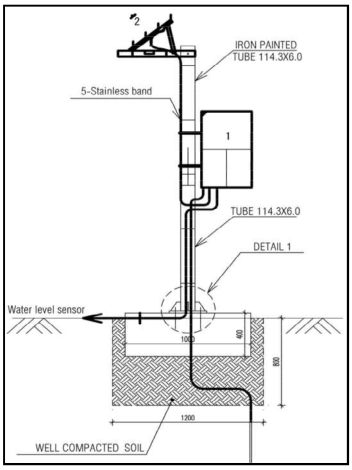


Figure 4-4.1 Gauging Station

4-4-1 Lightning countermeasure

Gauging stations are constructed in various places such as remote areas and nearby canals. Therefore, countermeasures against lightning and external noise are required. However, since the height of the gauging station's pole is 3m to 5m, it is not the height directly receiving lighting, so the function of lightning protection is only measures against induced lighting. Induction lightning is discharged to the ground through a surge protector.

4-5 Design of monitoring station

4-5-1Central monitoring station (Master station)

The central monitoring station (master station) will be installed in the same building of the control house for NDGRs. Table 4-5.1, Figure 4-5.1, and Table 4-5.2 show the function of central monitoring station, typical operation diagram of the master station and equipment in the master station, respectively.

Table 4-5.1 Function of the master station

No.	Function	Specification	Remarks
1	Data acquisition	Collected all the information which is measurement data from the gauging station by call.	
2	Water management	Making a report of all operation and management screens. And, installing the flow calculation	
3	Data base	Data base, data indication, data transferring, data store and restore	
4	Web server	The basis of the Water management screen is web display. This server provide the Water management screen to the WEB client.	
5	Mail server	The data are delivered to the mail address registered beforehand as information allows adding and remove addresses, address grouping... Etc.	
6	Monitoring	Monitoring the web screen. And, Print out.	
7	Network	LAN network	

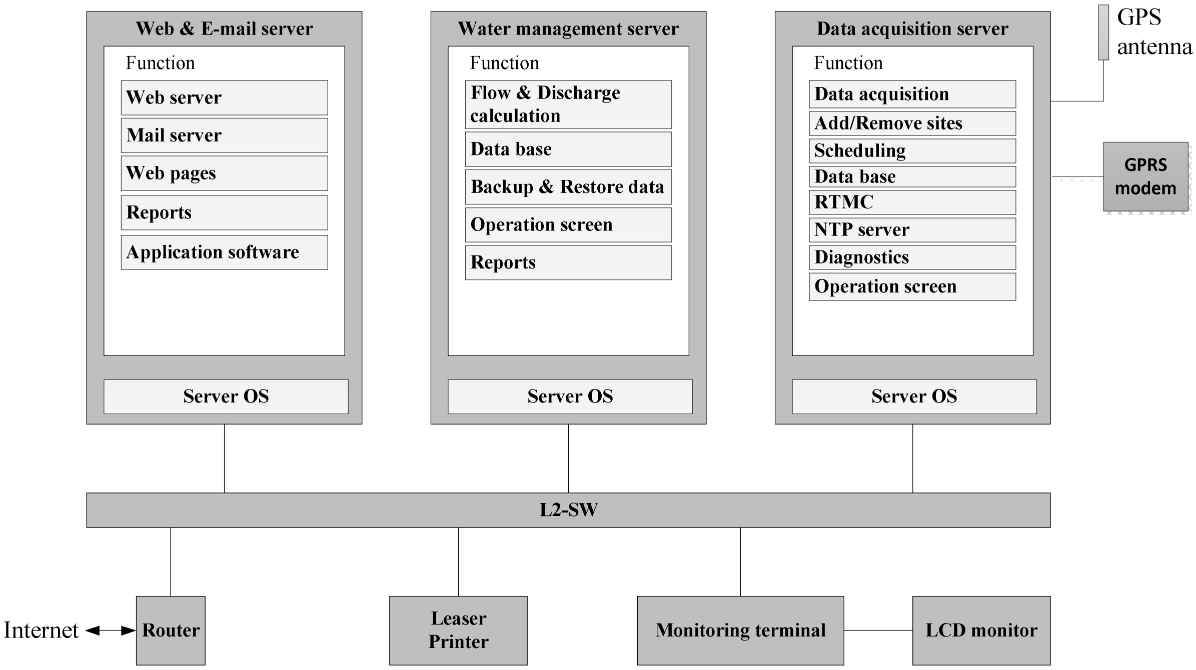


Figure 4-5.1 Typical operation diagram of the master station

Table 4-5.2 Equipment of the master station

No.	Equipment	Quantity	Remarks
1	GPRS modem	1	
2	Router	1	
3	L2-SW	1	
4	Data acquisition server	1	
5	Water management server	1	
6	Web & E-mail server	1	
7	NTP server	1	GPS antenna
8	KVM Switch	1	
9	KVM Monitor	1	
10	Keyboard & Mouse	1	
11	UPS	2	
12	Computer rack	1	
13	Monitoring terminal	1	
14	Laser printer	1	
15	LCD Monitor	1	

4-5-2 Minia monitoring station

Minia monitoring station will be set in telemetry office in Minia district. Table 4-5.3, Figure 4-5.2, and Table 4-5.4 show the function of monitoring station, typical operation diagram of monitoring station and equipment in the monitoring, respectively.

Table 4-5.3 Function of the monitoring station

No.	Function	Specification	Remarks
1	Monitoring	Monitoring the web screen. And, Print out.	
2	Network	LAN network	

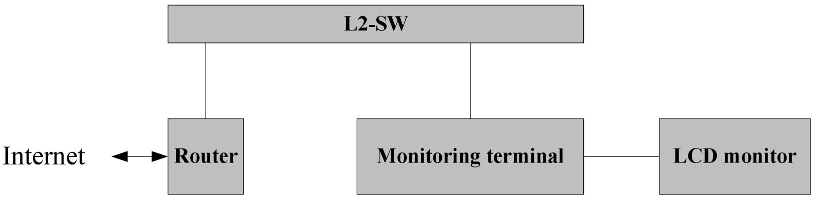


Figure 4-5.2 Typical operation diagram of the monitoring station

Table 4-5.4 Equipment of the monitoring station

No.	Equipment	Quantity	Remarks
1	Router	1	
2	L2-SW	1	
3	UPS	2	
4	Monitoring terminal	1	
5	LCD Monitor	1	

4-6 Specifications for equipment

4-6-1 GPRS modem

GPRS model shall be plug-in type and have moisture-proof type. The GPRS modem is a device for using the GPRS service of the mobile phone network and has a function for connecting to this network. The GPRS modem connects to the communication network of the mobile company of the built-in SIM card. The GPRS modem modulates data such as the water level from the RTU into a signal for GPRS communication and sends a modulation signal to the mobile phone network. Also, the modulated signal from the mobile phone network is received by the GPRS modem and then demodulated into predetermined data. The functions of the GPRS modem are shown in Table 4-6.1. The detailed contents are described in the technical specification.

Table 4-6.1 Technical specifications for GPRS modem

1)	Cellular interface	GSM / GPRS
	Frequency	Dual-band or more
2)	SIM Card	Two (2) slots or more
3)	Antenna interface	External Antenna
4)	Data interface	One (1) port or more
	Type	Serial port (RS232) or equivalent
	Baud rate	110 to 38,400 bps or more
5)	Command	AT commands or equivalent
6)	Health and Status monitoring	LED indicator
7)	Power	DC 12 V +/- 2V
8)	Standard	IP65 or more
9)	Mounting method	DIN rail or Screw mount
10)	Auxiliary	External antenna, The dedicated cable between modem and antenna
11)	Operating Temperature	10° to 55°C

4-6-2 RTU

RTU shall be plug-in type and have moisture-proof type construction, and consist of the following function, serial interface, I/O interface (external signal input / output), I/O interface controller and data exchange. This controller shall control these interface and functions according to user program.

RTU shall have the following function,

a) Transmission control

- To transmit the measured data and/or alarm and status data to Data acquisition server through GPRS modem.
- To receive control signal from Data acquisition server through GPRS modem.

b) I/O signal interface

- To read the analogue input signal value from the water level sensor, the range of the analogue input signal shall be 0 - 5 Volt or 4- 20 mA.
- To read the digital input signal status, the input signal shall be high / low condition (0 volt/5 volt) or open / close state. The input interface shall be electronically isolated.
- The spare port of I/O interface shall remain around 25% at all number of port.

c) Clock synchronizes

- The internal clock is regularly corrected. An internal clock synchronizes with NTP server in the master station, and this correction is completed.
- The protocol used by this clock synchronization shall be NTP. Moreover, NTP client shall be installed in RTU for calibrating an internal clock.

d) Data memory

- To store the data measured (analogue or digital) in the data logger to be retrieved when needed.

e) Power supply

- To supply the electrical power to each sensor. The voltage shall be 12VDC.

f) Data convert

- The data measured is received with Analog signal input port will be corrected according to meteorological conditions and a geographic condition. The measurement value after it corrects it is converted into the water level.

g) Internal control program

- The controller shall control these interface and functions according to user program. The Contractor shall prepare the user program which must work all function.

The specification is shown in Table 4-6.2. The detailed contents are described in the technical specification.

Table 4-6.2 Technical specifications for RTU

1)	Communication interface (for GPRS modem)	One (1) port or more
	Type	Ethernet (RJ45) or Serial port (RS232) or equivalent
	Speed	10/100 Base @ Ethernet, 110 to 38,400 bps @ Serial port or more
2)	External data interface (for Datalogger)	One (1) port or more
	Type	Ethernet (RJ45) or Serial port (RS232) or equivalent
	Baud rate	10/100 Base @ Ethernet, 110 to 38,400 bps @ Serial port or more
3)	I/O Interface	Spare port shall be set 25%.
	Analog signal input	8 ports or more, Analog (4-20mA, 0-5V), Isolation or line arrester shall be provided
	Digital signal input	12 ports or more, High/Low condition or Open/Close state (0 volt / 5 volt) or BCD 4 digits. Isolation or line arrester shall be provided
	Digital signal output	8 ports or more, High/Low condition or Open/Close state (0 volt / 5 volt) or BCD 4 digits.
4)	Protocol	IP, TCP, SNMP, NTP or more
5)	Health and Status monitoring	LED indicator
6)	Power	DC 12V +/- 2V
7)	Standard	IP65 or more
8)	Mounting method	DIN rail or Screw mount
9)	Operating Temperature	10° to 55°C

4-6-3 Data logger

Data logger shall consist of data logging and serial interface. Data logger enables to build it into RTU. Data logger shall fully satisfy the following function;

a) Data logging and display

- The converted water level data and current time are stored in the internal memory, and displayed on LCD display too by automatically or manually. The displayed time will be synchronized with internal clock or equivalent. For manual control, some buttons and LCD display must be located on the outlet of RTU. These data from internal memory is read, and displayed on LCD display too.

b) Clock synchronizes

- The internal clock is regularly corrected. An internal clock synchronizes with NTP server in the master station, and this correction is completed. The protocol used by this clock synchronization shall be NTP. Moreover, NTP client shall be installed in RTU for calibrating an internal clock.

c) Backup to external memory

- ➢ The external memory shall be back up for internal memory. Backup of internal memory will automatically execute a few times a day. Also, this backup can manually execute when it requires. Moreover, anytime this external memory shall be taken and setup. The data format stored must be Standard ASCII/CSV/XML. The data will be stored as permanent nonvolatile data. The storage period shall be for one (1) year and more.

d) Data memory

- ➢ To store the data measured (analogue or digital) from RTU and other to be retrieved when needed. The data will be stored as permanent non volatile data. The storage period shall be for one (1) year or more.

The specification is shown in Table 4-6.3. The detailed contents are described in the technical specification.

Table 4-6.3 Technical specifications for data logger

1)	External data interface (for RTU)	One (1) port or more
	Type	Ethernet (RJ45) or Serial port (RS232) or equivalent
	Speed	10/100 Base @ Ethernet, 110 to 38,400 bps @ Serial port or more
2)	Internal memory	One (1) Gbyte or more
3)	External memory	SD-Card FAT-16 or equivalent
4)	Protocol	IP, TCP, SNMP, NTP or more
5)	Maintenance port	One (1) port or more, Serial port (RS-232) or equivalent
6)	LCD display	Two (2) lines or more
7)	Health and Status monitoring	LED indicator
8)	Power	DC 12V +/- 2V
9)	Standard	IP65 or more
10)	Mounting method	DIN rail or Screw mount
11)	Operating Temperature	10° to 55°C

4-6-4 Water level sensor

Water level sensor shall be equipped a semi-conductor type pressure sensor which converts a pressure into a voltage or current. Water level sensor shall compose the sensor which is pressure type and the dedicated cable which shall be covered by the suitable pipe and fixed on the concrete structure or other approved method.

Water level sensor shall be designed to be protected from a lightning surge. Output signal shall be of the Analog 4 to 20 [mA] or equivalent for RTU.

Protective device with box to prevent the sensor and RTU from the lightning surge shall be provided at both end (when the distance between the water level sensor and RTU is short, one protective device is acceptable).

The specification is shown in Table 4-6.4. The detailed contents are described in the technical specification.

Table 4-6.4 Technical specifications for water level sensor

1)	Type	Pressure sensitive diffusion type semi-conductor or equivalent
2)	Measuring range	According to site specification
3)	Cable length	According to site specification
4)	Accuracy	± 0.10 % at F.S. at constant temperature, ± 0.2% over 35°F to 70°F(1.37° to 21.1°C) range
5)	Output signal	Analogue signal 0-5 volt or 4 - 20 mA or equivalent
6)	Sensor element	Titanium
7)	Sensor body	Stainless steel

4-6-5 Server

Server is manufactured based on the latest computer technology and ensure the trouble-free operation.

The basic component shall be composed of processor, serial interface, Local Area Network (LAN) interface, keyboard, color display monitor, Operating Software (OS) and shall be of the hot-standby system due to improve the system reliability.

The processor of computer shall be quad core and more.

Server shall be connected on LAN and shall prepare a necessary interface for peripheral devices.

Main memory shall be prepared a sufficient capacity, at least more than ten (10) years of data storage, and shall perform all process tasks without mutual interface and shall be provided efficient execution of all programs supplied by the Contractor and to cater for future expansion of the system.

LAN interface shall be suitable to Ethernet and protocol shall be based on TCP/IP (Transmission Control Protocol / Interface Protocol).

Operating System (OS) shall be selected from the “De Facto Standard” such as Windows, or Linux etc. Programming language shall be workable in the Windows, or Linux etc., which have used widely in the world. Anti-virus and screen saver software shall be provided to the server.

The specification is shown in Table 4-6.5. The detailed contents are described in the technical specification.

Table 4-6.5 Technical specifications for server

1)	Type	Computer rack mount
2)	CPU	Intel Xeon E5 or more
3)	Memory	16.0 GB or more
4)	HDD	8.0 TB (RAID5/Hot plug) or more
5)	RAID	RAID level 5 or more
6)	External drive	DVD-ROM/DVD-RW/DVD-R or equivalent
7)	Buck up System	Hot-Standby system
8)	I/O Interface	Two or more ports - 10/100/1000 BASE-TX
		Two or more ports - Serial port (RS232C)
		Four or more ports - USB 3.0
9)	Power	AC 230V +/-10 %, 50 Hz +/- 2 Hz, Dual supply/Hot plug
10)	OS	Windows Server 2016 English version or equivalent
11)	Apprication software	Apprication software that satisfies a specified function and the performance must be installed with OS.
12)	Waranty	5years
13)	Operating Temperature	10° to 55°C

4-6-6 Personal Computer

Personal Computer (PC) shall be factory automation (FA) type PC and shall be used to control and connect to Server via, Network.

The basic component shall be composed of processor, serial interface, Local Area Network (LAN) interface, keyboard, color display monitor and Operating Software (OS).

The processor of computer shall be quad core and more. It shall be connected on LAN and shall prepare a necessary interface for peripheral devices.

Main memory shall be prepared a sufficient capacity, at least more than ten (10) years of data storage, and shall perform all process tasks without mutual interface and shall be provided efficient execution of all programs supplied by the Contractor and to cater for future expansion of the system.

LAN interface shall be suitable to Ethernet and protocol shall be based on TCP/IP (Transmission Control Protocol / Interface Protocol).

Operating System (OS) shall be selected from the “De Facto Standard” such as Windows, or Linux etc. Programming language shall be workable in the Windows, or Linux etc., which have used widely in the world. It shall have function to update display data automatically using Java language or equivalent. Anti-virus and screen saver software shall be provided to the server.

The specification is shown in Table 4-6.6. The detailed contents are described in the technical specification.

Table 4-6.6 Technical specifications for personal computer

1)	Type	Factory Automation Type
2)	CPU	Intel Core i7, 2.0 GHz or more
3)	Memory	4.0 GB or more
4)	HDD	1.0 TB or more
5)	External drive	DVD-ROM/DVD-RW/DVD-R
6)	I/O Interface	Two or more ports - 10/100/1000 BASE-TX
		Two or more ports - Serial port (RS232C)
		Four or more ports - USB 3.0
7)	Power	AC 230V +/-10 %, 50 Hz +/- 2 Hz
8)	OS	Windows 8.1 Pro English version or equivalent
9)	Apprication software	Apprication software that satisfies a specified function and the performance must be installed with OS.
10)	Auxiliary	Cable, TFT LCD monitor (21inch or more), Keyboard & Mouse
11)	Waranty	5years
12)	Operating Temperature	10° to 55°C

4-6-7 LCD monitor

The LCD monitor is a device for displaying observed data such as schematic diagram of integrated water management system, measured water level sensor, gauging station with abnormal power supply status and etc. LCD monitor can be set up as follows, wall mounting, the self-stand mounting, and the ceiling mounting.

The specification is shown in Table 4-6.7. The detailed contents are described in the technical specification.

Table 4-6.7 Technical specifications for LCD monitor

1)	Display size	60 inch or more
2)	Display type	Liquid Crystal Display
3)	Resolution	1,280 x 1,024 dot or more
4)	PC interface	Analogue RGB (mini D-sub 15 pin) x 1 or equivalent
5)	Video interface	(Input) NTSC x1 or equivalent
		(Input) HDMI x3
		(Output) NTSC x1 or equivalent
		(Output) HDMI x1
6)	Installation	The wall mounting, the self-stand mounting, and the ceiling mounting
7)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
8)	Operating Temperature	10° to 55°C

4-6-8 L2-SW

L2-SW shall be hub where the switching facility is added, and shall learn the MAC address of Ethernet device connected to each port, and link port required for intelligence directly and enable it exchange data.

The specification is shown in Table 4-6.8. The detailed contents are described in the technical specification.

Table 4-6.8 Technical specifications for L2-SW

1)	LAN interface	10BASE-T/100BASE-TX x 8 ports or more
2)	LAN protocol	TCP/IP, IP multi-cast, etc
3)	Layer 2 switching	Shall be Provided
4)	Maximum VLAN	Approx. 63 or more
5)	VLAN trunk	Shall be Provided
6)	Spanning tree	Shall be Provided
7)	Multicast	IGMP etc
8)	Connector	RJ-45 jacks
9)	Network management	SNMP
10)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
11)	Switching Function	Frame forwarding ability is 10.0 Mbps or more
		Switching method shall be Store and-forward
		The priority control of traffic must be possible based on COS, TOS, and the DSCP value of priority control IEEE802.1p.
		Several 127 to which the VLAN function can be set VLAN or more of each port can be set and tag VLAN (IEEE802.1Q) should be able to be set.
		Independent spanning tree protocol operation (Tag VLAN is contained) at each trouble detour VLAN MSTP (IEEE802.1s) and RSTP (IEEE802.1w).
		The multicast packet is forwarded only to a necessary multicast port (IGMP Snooping equivalent function).
		Possess the function (Storm Control equivalent function) to suppress a large amount of Broadcast, Multicast, and Unicast by the traffic control each other port.
12)	Management function	Management protocol SNMP (v1,v2,v3)
		Remote access function by remote triggering Telnet
13)	Operation and maintenance function	Limitation access. By password
		Preservation, remote maintenance, and the log output of composition definition information by the set management text form must be possible.
		Power On automatically after it electrical power failure.
14)	Operating Temperature	10° to 55°C

4-6-9 Router

Router shall be equipped with the connection function conformed to intranet provided for accessing to internet. Router shall be connected when transmission with an external network between Master station and other government office.

The specification is shown in Table 4-6.9. The detailed contents are described in the technical specification.

Table 4-6.9 Technical specifications for router

1)	IP routing protocol	RIP, RIPv2
		Number of route entries is 5000 or more
2)	WAN protocol	To be suitable internet line provided by communication company
		PPP, PPPoE, IPv4
		Number of PPPoE session is 100 or more
3)	LAN protocol	IPv4, TCP, UDP, Multicast
4)	LAN ports	RJ45 type
		10BASE-T/100BASE-TX
		8 ports or more, (all port supports MDI/MDI-X)
5)	WAN ports	To be suitable intranet and internet line provided
6)	Throughput	50 Mbps or more
7)	NAT descriptor function	NAT, IP masquerade, Static NAT, DMZ, PPTP pass through,
		IPsec pass through
		Number of NAT session is 10,000 or more
8)	Quality of Control (QoS) function	Priority control, Traffic control (Dynamic traffic control),
		Support for CBQ, WFQ,
9)	VPN function	IPsec (NAT traversal, XAUTH)
		Encryption; AES, DES (Hardware processing)
		IKE/IKEv2, PPTP
10)	Authentication function	PAP/CHAP,MS-CHAP/MS-CHAPv2 or more
11)	Firewall function	IP address, Protocol, Destination / Source, Port number
		Number of static session filter is 1000 or more
		IDS detection, SYN flag attacking is blocked automatically
12)	Security function	URL filtering
		MAC address filtering
13)	Management function	Management protocol SNMP(v1,v2,v3)
		Remote access function by remote triggering Telnet
14)	Operation and maintenance function	Limitation access. By password
		Preservation, remote maintenance, and the log output of composition definition information
		Power On automatically after it electrical power failure.
15)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
16)	Operating Temperature	10° to 55°C

4-6-10 Laser printer

A laser printer is a device for outputting information processed by integrated water management.

The specification is shown in Table 4-6.10. The detailed contents are described in the technical specification.

Table 4-6.10 Technical specifications for laser printer

1)	Printing method	Electro photographic laser beam scanning
2)	Data process resolution	600 x 600 dpi or more
3)	Paper size	A4, A3 or more
4)	Network connection	10BASE-T/100BASE-TX
5)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
6)	Operating Temperature	10° to 55°C

4-6-11 Enclosure

Enclosures for equipment shall be wall mounting, rigid welded steel frames, completely enclosed by metal sheets and suitable for outdoor installation. It shall have provisions for lifting and ample strength to withstand all stresses incidental to shipping, installation and operation without distortion or other damage. Enclosure in the gauging station shall be set up the following equipment;

- GPRS modem with antenna

- RTU
- Data logger
- Power charge controller
- Storage battery
- Surge protector

The specification is shown in Table 4-6.11. The detailed contents are described in the technical specification.

Table 4-6.11 Technical specifications for enclosure

1)	Construction	Outdoor pole-mounting
2)	Material	Steel plate, and it shall be coated with anti-corrosive paint
3)	Dimension	W600 x D200 x H600 mm or equivalent
4)	Locking system	Key
5)	Standard	IP65 or more
6)	Operating Temperature	10° to 55°C

4-6-12 Computer rack

Computer rack shall be IP20 degree of protection and be dead-front, floor mounting, rigid welded steel frames, completely enclosed by steel plates. It shall have provisions for lifting and ample strength to withstand all stresses incidental to shipping, installation and operation without distortion or other damage. Computer rack shall be set up the following equipment;

- GPRS modem with antenna
- Data acquisition server
- Water management server
- Web & Mail server
- L2-SW
- Router
- UPS
- KVM switch, monitor, keyboard and mouse
- Extension Tap

The specification is shown in Table 4-6.12. The detailed contents are described in the technical specification.

Table 4-6.12 Technical specifications for computer rack

1)	Construction	Indoor self-standing (19 inch rack)
2)	Material	Steel plate
3)	Dimension	W600 x D600 x H2,000 mm or equivalent
4)	Thickness of plate	1.6 mm or more
5)	Operating Temperature	10° to 55°C

4-6-13 LCD KVM switch

LCD KVM switch integrates a LCD panel, full keyboard and touchpad into a streamlined, 1U housing of the computer rack. This shall be rack mount type. LCD KVM switch allows a user to control multiple Server and/or Computers from one or more sets of Keyboards, VGA monitors and Mousse. Although multiple Server and /or Computers are connected to KVM switch.

LCD panel capable of full HD video incorporates the YUV video format for greater compatibility with high-definition signals (e.g. NVR sources). Similarly, this is also High-Bandwidth Digital Content Protection (HDCP) compatible.

The specification is shown in Table 4-6.13. The detailed contents are described in the technical specification.

Table 4-6.13 Technical specifications for LCD KVM switch

1)	Server (Computer) connection	8 [nos]
2)	Port selection	OSD, Hotkey, Pushbutton
3)	Connectors	
	External ports	USB type A (Female) 2 ports (or PS/2 (Female) 2 ports), Stereo Mini Jack (Female) 1 port, DVI-I (Female) 1 port (or VGA (Female) 1 port)
	KVM Ports	USB type A (Female) 4 ports (or PS/2 (Female) 4 ports), Stereo Mini Jack (Female) 4 ports, DVI-I (Female) 4 ports (or VGA (Female) 4 ports)
4)	Emulation (Keyboard / Mouse)	USB or PS/2
5)	LCD panel	
	Screen size	17 inch or more
	Support color	262144 colors
	Luminance	300 cd/m^2 or more
	Response time	less than 8 ms
6)	Video	1920 x 1080 or more
7)	Scan Interval	1 to 255 sec.
8)	Mount type	Computer rack mount
9)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
10)	Operating Temperature	10° to 55°C

4-6-14 NTP server

NTP server shall provide accurate year, month, day, hour and minute data via LAN network. GPS receiver shall be built into NTP server, and shall be connected to the external GPS antenna. GPS receiver in NTP server shall receive the signal from several GPS satellites in the sky, and GPS receiver shall get own present location and time.

GPS satellite is a semi-synchronous satellite that rounds and moves highly of about 20,000km in about 12 hours. And this is not a fixed satellite. In view of the point on a certain earth, GPS satellite changes the position hour by hour. Therefore, the error margin can be leveled on the all earth. However, the number of GPS satellites that can be received is according to the region on the earth and there are always few places, too.

Information on the data of time from the atomic clock installed in the GPS satellite and the astronomical ephemeris of the satellite are included in the signal from the GPS satellite to GPS receiver. GPS receiver in NTP server shall receive the wave from GPS satellite, and measures the sending time. GPS receiver shall calculate the distance from GPS satellite by using the speed of the wave (the same 300,000km/second as the speed of optical light) for the difference of a time of the transmission and the reception.

The clock installed by GPS receiver is using Quarts. Therefore, this clock is not accurate. For example, the error margin of the calculated distance becomes about 300m when the error margin of GPS receiver at time is 1/1,000,000 seconds. To secure the accuracy of this clock, GPS receiver receives the wave from four GPS satellites, and calculates accurate reception time and the receiver coordinates by the measurement calculation.

GPS time shall be UTC which began a start time from January 6, 1980 (standard time). Moreover, the leap second adjustment is not executed like UTC. The difference data of the time between GPS time and UTC is included in GPS receiving data. Therefore, NTP server is outputting the accurate UTC calibrated by using difference data. And, there is an offset signal to which this time difference is corrected up to 255 (eight bits). This means that it is possible to use it until 2300yr without trouble in case of the leap second insertion of current state correction.

The specification is shown in Table 4-6.14. The detailed contents are described in the technical specification.

Table 4-6.14 Technical specifications for NTP server

1)	GPS receiver	Built-in, 6-channel GPS C/A-code receiver or equivalent
2)	GPS antenna	External
3)	Accuracy (time)	less than 1 ms GPS synchronized,
4)	Accuracy (frequency)	less than 1E-11 GPS synchronized, avg, over 24 hours
5)	Output	10/100 Base Ethernet
6)	LAN interface	RJ45, One (1) port or more
7)	Serial interface	One (1) port or more
8)	Supported network protocol	NTP(V2, v3, v4), SNMP(v3,v4), IP, DHCP(client), Secured protocol
9)	Health and Status monitoring	LED indicator
10)	Mount type	Computer rack mount or Standalone
11)	Accessory	Surge arrestor, The dedicated cable between the receiver and antenna
12)	Power	AC230 V +/-10 %, 50 Hz +/- 2 Hz
13)	Operating Temperature	10° to 55°C

5. Operation and Maintenance Plan for Integrated Water Management

The purpose of introducing the integrated water management system is to monitor the irrigation facilities such as the regulators, the branch canal intakes and the pump stations, etc. in a centralized monitoring, thereby making effective use of irrigation water in the beneficially area, rational water allocation, securing safety of irrigation facilities, and reducing operation and maintenance cost of each facility. As irrigation facilities are widely scattered in the Project area, operation and maintenance manuals of the integrated water management system are necessary for these effective operations.

In addition, it is needed the certain level of training of data gathering, data evaluation and data utilization at the one site via the remote monitoring system and gate operation techniques for establishing the appropriate gate operation of NDGRs which was constructed this project, resolving the unbalanced water distribution at each site along Ibrahimia and Bahr Yusef canal with a length of more than 300 km.

The contents of technical cooperation for operation and maintenance for establishment of the appropriate operation in the near future are described below. And following figure mentions the position of strengthening program framework after the completion of this project.

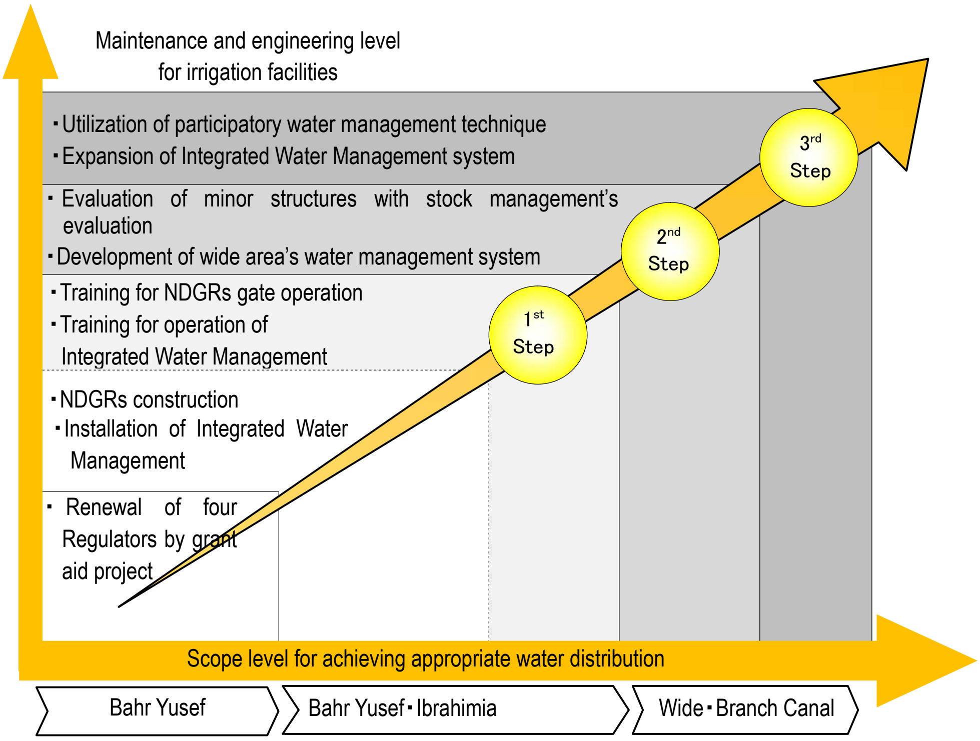

Maintenance and engineering level for irrigation facilities
・Utilization of participatory water management technique
・Expansion of Integrated Water Management system
・Evaluation of minor structures with stock management's evaluation
・Development of wide area's water management system
・Training for NDGRs gate operation
・Training for operation of Integrated Water Management
・NDGRs construction
・Installation of Integrated Water Management
・Renewal of four Regulators by grant aid project
1st Step
2nd Step
3rd Step
Scope level for achieving appropriate water distribution
Bahr Yusef
Bahr Yusef・Ibrahimia
Wide・Branch Canal

Figure 5-1.1 Position of strengthening program framework and project road map (draft)

The following proposal could be arisen as operation and maintenance activity in this project, which should be supposed as improvement of technical skills of Egyptian engineers. To achieve these outcomes, the draft technical topics and strengthening program contents are shown in Table 5-1.1.

(1) Through the project, the operation rules of NDGRs are formulated together with CP, and technical transfer will be carried out.

(2) Discharge measurement at the downstream of NDGRs and technical transfer of water distribution method will be carried out.

(3) In the NDGRs, a manual for gate operation and integrated water management method will be formulated together with CP

Table 5-1.1 Program for strengthening of operation and maintenance capacity (draft)

Topics	Contents of strengthening program	Example of specialized Japanese skilled expert
Gate operation technique for NDGRs	Training of gate operation skills for establishment of appropriate water distribution for seven canals	Irrigation development, Irrigation facility operation, Operation and maintenance, Electrical and mechanical
Maintenance skills of gate facilities for NDGRs	Maintenance skill's support for mechanical engineers due to conversion from human power driven gate operation to mechanical driven gate operation	Operation and maintenance, Electrical and mechanical, Telecommunication
Improvement of discharge measurement technique in major regulator and branch canal's intake	Technical and measuring equipment support for creating H~Q rating curve (relationship between water level and discharge)	Irrigation, Operation and maintenance, Hydraulics
Expansion of integrated water management technique	Technical support for gate operation of NDGRs and proper water distribution method at the regulators along the two main canals and branch canal's intake	Irrigation planning, Water management, Telemetry, Irrigation facility operation (Canal, Minor structure), etc.
Operational support for stakeholder meetings for appropriately operation of integrated water management technique	Cooperation with the Ministry of Agriculture and other governmental organizations such as MED related to latest irrigation area and cropping information.	Irrigation planning, Agriculture, Water management, GIS, Remote sensing

Operation and Maintenance Manual of Integrated Water Management System

1. Purpose of the Manual

The manual is prepared for rational water management and proper water distribution at the NDGRs, primary canals, main canals and main branch canal's intakes by integrated water management system.

2. Concept of Water Management in the Area

Irrigation water of 9.6 billion m^3, taken from the Nile River, is diverted to the Ibrahimia Primary Canal. The water will be diverted from the NDGRs to the seven canals, and it is finally distributed among the 600,000ha beneficiary area by the Project. It means that proper water distribution to the seven canals will be implemented due to recovery of original functions of the Regulators.

Out of seven canals, the Bahr Yusef Canal and Ibrahimia Canal are very long, exceeding 300 km in length. By means of integrated management of scattered regulators in such wide area, effective water distribution targeting the five beneficiary Governorates, namely, Assiut, Giza, Beni Suef, Fayoum and Minia can be implemented. The Project establishes a monitoring system to operate water distribution in centralized manner for the purpose of dissolution of current imbalanced one.

In the integrated water management system to be installed by the Project, not only discharge at regulators which are located on the boundary of Governorates but also that at other regulators and branch canal intakes will be observed. In addition to establishment of such a centralized system in the remote areas, H-Q curve (water level – discharge) is to be prepared, and it is possible to estimate water volume by measured water level at regulators and branch canal intakes. It means that centralized data collection system makes it possible to evaluate the water discharge data and to give instruction for gate operation, which leads to proper and even water distribution at the level of main canal.

Expected outcomes by the integrated water management system are as follows:

・Rational water distribution

Identification of discharge in the main canal at the regulators, data collection of discharge from main canals to branch canals, just enough and proper water distribution, even water distribution based on water rights in governorates can be implemented. Water allocation is based on the amount of water actually supplied, which leads to fair water management.

・Awareness improvement of water distribution

It is possible for the third party to check the actual water distribution by centralized water management system and visual presentation of water level and water distribution conditions at plural sites. Moreover, some governorates, which interfere, can share the same data by the new visualized system, which leads to improve transparency of water distribution.

・Speed-up of giving instruction for water distribution

Since measured data collection is done in the centralized manner and instruction of water distribution is given based on the collected data, speedy instruction will be given.

・Improved operation & maintenance of irrigation facilities

Since water level discharge of targeted main irrigation facilities can be measured even in the remote area, it is possible to identify any accidents of facilities and improper water distribution immediately, when trouble and failure in water level data are observed. Due to the new system, repair at early stage and daily maintenance can be practiced.

3. Target Facilities

The target water management facilities are mainly 1) monitoring systems in the remote area to be installed by the Project, which are listed in Table 5-1.2 and Table 5-1.3, 2) the integrated water management system in the central control house at NDGRs, and 3) the monitoring room to be installed in Minia Governorate.

Specific targeted facilities are 1) Ibrahimia head regulator at the intake point from the Nile River, 2) NDGRs which diverts water from the Ibrahimia Primary Canal to the seven canals, 3) Regulators at Ibrahimia Canal and Bahr Yusef Canal, 4) branch canal’s intake at Ibrahimia canal and Bahr Yusef canal including pump stations, 5) weirs for discharge observation at main canals and branch canals, and 6) lake at the end of the Bahr Yusef Canal. In addition, 7) integrated water management system in the central control house at NDGRs, which centralizes measured water level in the remote areas, and 8) monitoring room in Minia Governorate are also targeted.

4. Administration Structure

The newly established “Integrated Water Management Center” will be in charge of management of the target facilities mentioned above. The center is under the Central Directorate for Water Distribution (CDWD) in Assiut, and it will be responsible for centralized operation and maintenance of the facilities.

The center is to be installed at the NDGRs control house. Under the center, four sectors shall be established and each sector manages East Minia, West Minia, Beni Suef and Fayoum, respectively. It is possible for the staff to double plural sections.

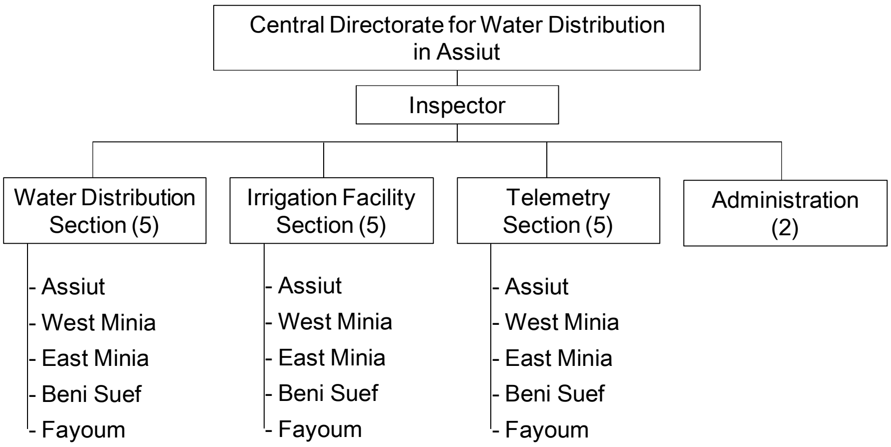


Figure 5-1.2 Organization chart of the new integrated water management center

5. Roles and Responsibility of the Integrated Water Management Center

Roles and responsibility of the Integrated Water Management Center are stipulated in the manual. The Center will be in charge of following matters:

(1) Operation and maintenance of the facilities

(2) Operation of facilities by close communication with CDWD in Assiut, and speedy and proper implementation based on the instruction by the CDWD

(3) Close monitoring of the canal conditions and handling of any issues as required

(4) Works for water distribution

  1) Observation of water level in the facilities listed in Table 1

  2) Decision of discharge at the regulators and discharge to be distributed to the branch canal intakes

  3) Instruction of gate operation at the regulators

  4) Instruction of gate operation at the branch canal intakes

  5) Instruction of pump station operation

  6) Others

(5) Works for operation & maintenance

  1) Cleaning and adjustment of the remote area observation equipment (water level meter, data logger, transmitter and so on）

  2) Cleaning and adjustment of the integrated water management system equipment in the Central monitoring & operating house and the Minia monitoring room

  3) Prevention of damage to the facilities

  4) Early identification of damage to the facilities and immediate repair

5) Thief proof of equipment

6) Control of excessive irrigation water use at the target facilities

7) Others

6. Works for Water Distribution

Works for water distribution mentioned in 5(4) are as follows:

(1) Any other organizations except those under the General Directorates of Irrigations (GDIs) shall not touch the gate operation.

(2) Integrated Water Management Center shall confirm whether water is distributed at regulators and branch canals as planned. (H-Q curve will be formulated gradually from the 3rd year after the start of NDGRs construction, and the draft H-Q curve will be tried after the completion of construction works.)

(3) Discharge at the regulators and water volume to be distributed to the branch canals are to be determined based on “Water Distribution Regulation”.

(4) Integrated Water Management Center basically shall confirm three times per day whether water is distributed through the integrated water management system as planned. According to necessity, it shall give instruction to GDIs regarding operation adjustment at regulators and branch canal intakes.

(5) Main gates at regulators and branch canal intakes shall be locked to prevent from illegal water diversion.

7. Works for Operation & Maintenance

Works for operation & maintenance mentioned in 5(5) are as follows:

(1) If minor issues are identified, the staff shall handle them.

(2) If there are some issues which cannot be managed in previous item, namely, 7 (1), the staff shall report them to the superiors and follow the instructions.

8. Water Distribution Methodology

Water volume to be distributed at the irrigation facilities are determined based on the Water Distribution Plan prepared by the NDGRs Project.

9. Record of Works

Integrated Water Management Center shall record the observed water level in the monthly report and submit it to the CDWD in Assiut.

10. Countermeasures against Water Shortage at the Ibrahimia Head Regulator

If water intake volume at Ibrahimia Main Canal from the Nile River is limited, which results in water shortage in the command area, the Integrated Water Management Center shall discuss with GDIs to take countermeasures against the issue.

11. Maintenance

Facilities and equipment mentioned in “3. Target facilities” shall be regularly maintained to keep original functions.

12. Inspection

For the purpose of functioning of the Integrated Water Management System, daily inspection and regular check shall be implemented. These works shall be done following the criteria:

1) Daily check: Minimized check for daily operation
2) Regular inspection: The staff shall monitor the equipment regularly to identify any errors from outside and implement operation tests, trial measurement, exchange of spare parts, repair, adjustment, cleaning and so on to recover the original functions of the equipment. The inspection frequencies are quarterly, biannually and annually depending on the inspection items.

Table 5-1.2 Facilities targeted for monitoring (1/2)

Irrigation facilities			Name of the Target facilities		No.
Regulator	Bahr Yusef canal		Dahab Regulator Sakoula Regulator Mazoura Regulator	Lahoun Regulator Abo El Shekok Regulator Regulator km39	6
	Ibrahimia canal		New Hafze Regulator Matay Regulator Maghagha Regulator	Sharahna Regulator El Gandy Regulator Ashmont Regulator	6
Branch canal	Bahr Yusef canal	Intake	Manshat EL Dahab El Hareka El Sabaa	Quftan Wesh El-Bab EL-Giza	6
		Weir	Hassan Wasef Weir		1
		Pump	New Kamdeer P.S. New Terfa P.S. Old Terfa P.S.	Old Sakoula P.S. Mazoura P.S.(2)	5
	Ibrahimia canal	Intake	Irad El Maharak El Kosia East Hafze West Hafze Adkak	Gendia Abo Shosha EL Soultany Tansa El Mansour	10
		Weir	Serry Weir	Maghagha Weir	2
Ibrahimia main canal			Ibrahimia Head Regulator		1
Lake			Quarun Lake		1
Total					38

Table 5-1.3 Facilities targeted for monitoring (2/2)

Irrigation facilities	Name of the Target facilities		No.
Dirout Group of Regulators	Bahr Yusef Regulator Ibrahimia Regulator Irad Delgaw Regulator Abo Gabal Regulator	Badraman Regulator Dairotiah Regulator Sahelyia Regulator	7
Total			7

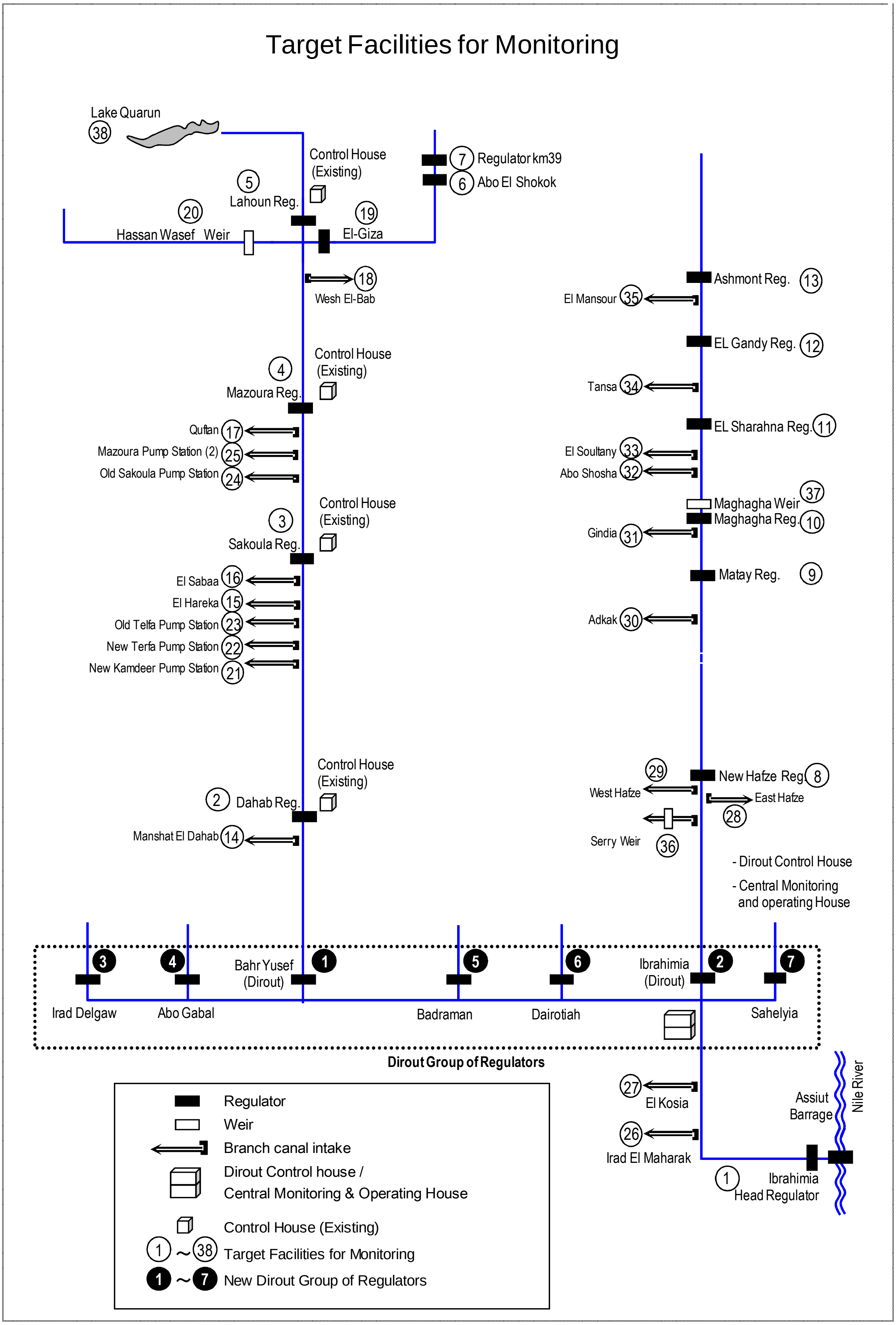


Figure 5-1.3 Schematic diagram of the facilities to be monitored in water management system

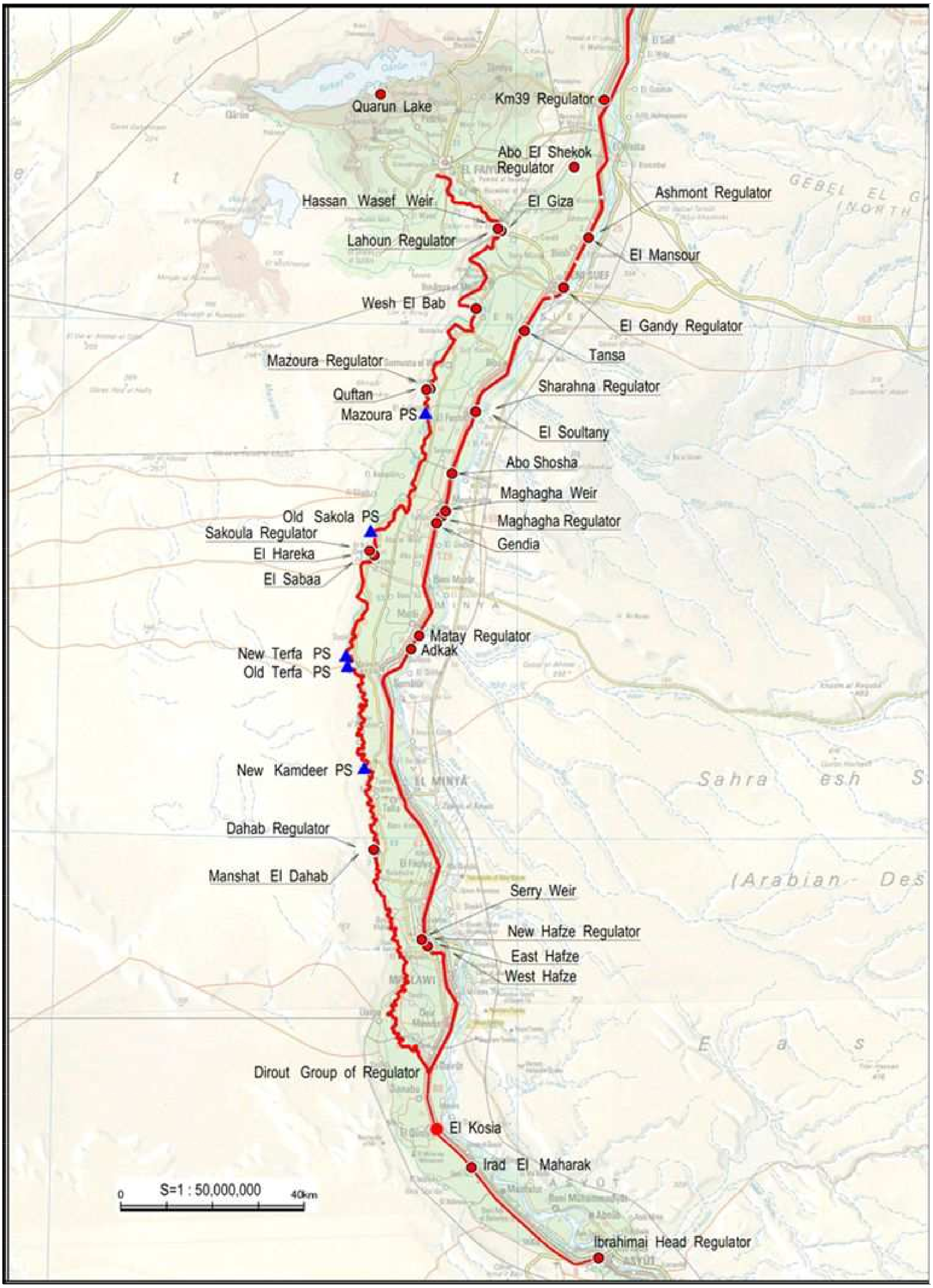


Figure 5-1.4 Location map

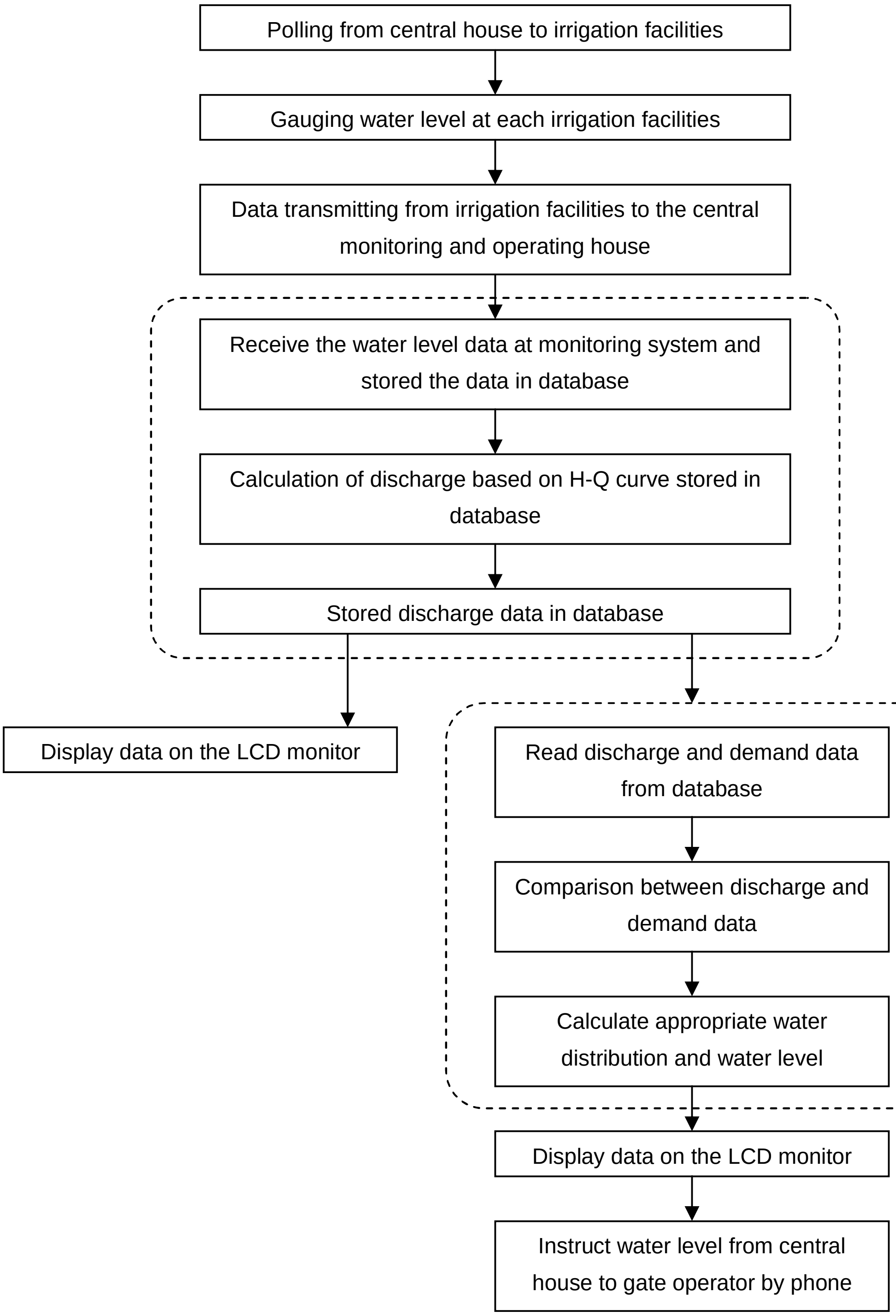

Polling from central house to irrigation facilities
Gauging water level at each irrigation facilities
Data transmitting from irrigation facilities to the central monitoring and operating house
Receive the water level data at monitoring system and stored the data in database
Calculation of discharge based on H-Q curve stored in database
Stored discharge data in database
Display data on the LCD monitor
Read discharge and demand data from database
Comparison between discharge and demand data
Calculate appropriate water distribution and water level
Display data on the LCD monitor
Instruct water level from central house to gate operator by phone

Figure 5-1.5 Data flow

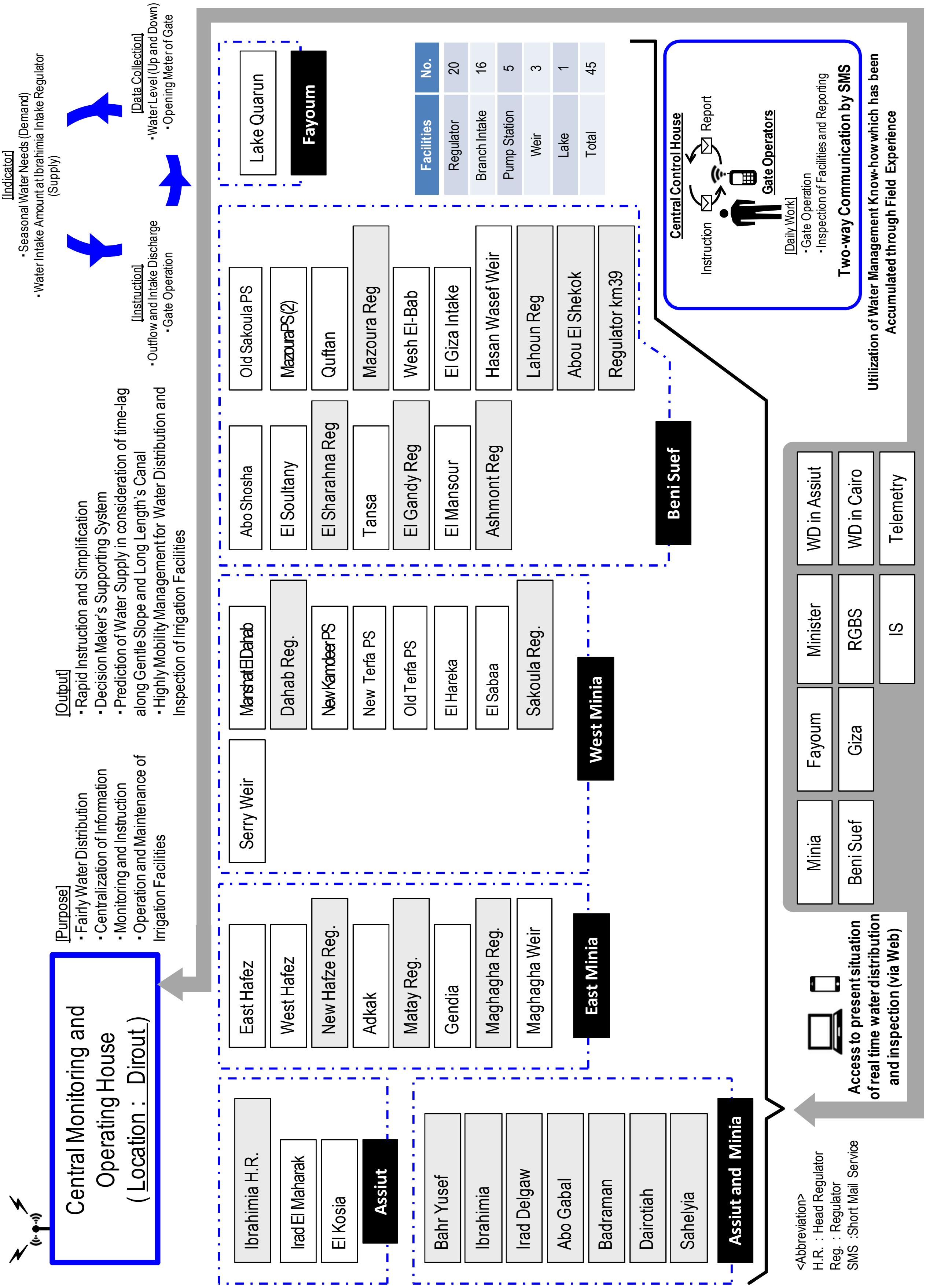


Figure 5-1.6 Hierarchic diagram for the integrated water management system

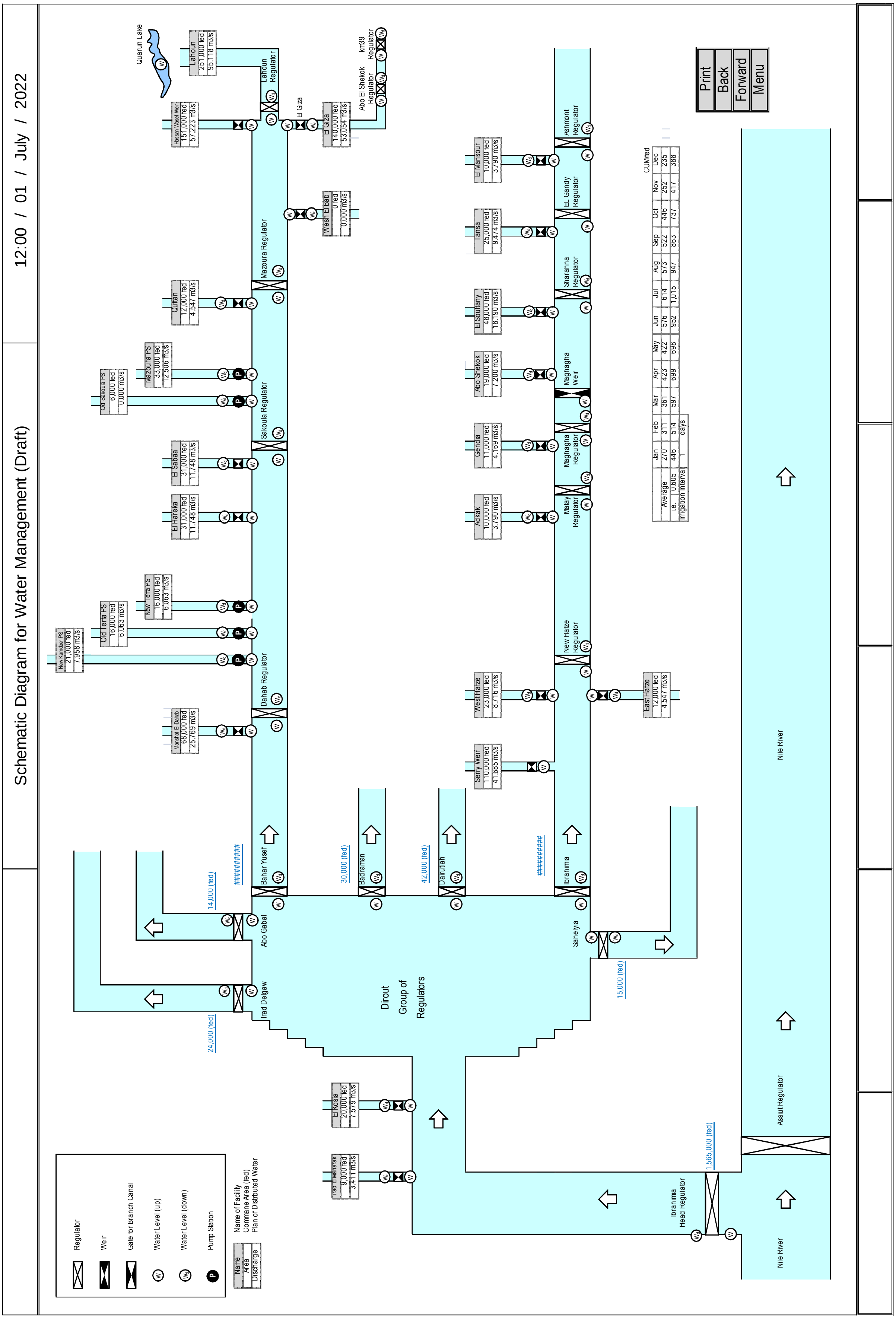

12:00 / 01 / July / 2022
Schematic Diagram for Water Management (Draft)
Print
Back
Forward
Menu
Quarun Lake
Lahoun 25,000 fed 95.118 m3/s
Lahoun Regulator
km39 Regulator
Abo El Shekok Regulator
El Giza
El Giza 140,000 fed 53.054 m3/s
Hassan Wasef Weir 151,000 fed 57.223 m3/s
Wesh El Bab 0 fed 0.000 m3/s
Mazoura Regulator
Qoftan 12,000 fed 4.547 m3/s
Mazoura PS 33,000 fed 12.506 m3/s
Old Sakoula PS 0,000 fed 0.000 m3/s
Sakoula Regulator
El Sabaa 31,000 fed 11.748 m3/s
El Hareka 31,000 fed 11.748 m3/s
New Tera PS 16,000 fed 6.063 m3/s
Old Tera PS 16,000 fed 6.063 m3/s
New Kamber PS 21,000 fed 7.958 m3/s
Dahab Regulator
Manshat El Dahab 68,000 fed 25.769 m3/s
El Mansour 10,000 fed 3.790 m3/s
Ashmont Regulator
Tansa 25,000 fed 9.474 m3/s
EL Gandy Regulator
El Soultany 48,000 fed 18.190 m3/s
Sharanna Regulator
Abo Shekok 19,000 fed 7.200 m3/s
Maghagha Weir
Gendia 11,000 fed 4.169 m3/s
Maghagha Regulator
Adkak 10,000 fed 3.790 m3/s
Matay Regulator
New Hatze Regulator
West Hatze 23,000 fed 8.716 m3/s
East Hatze 12,000 fed 4.547 m3/s
Serry Weir 110,000 fed 41.685 m3/s
CUM/fed
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Average 270 311 361 423 422 576 614 573 522 446 252 235
i.e. 0.605 446 514 597 699 698 952 1,015 947 863 737 417 388
Irrigation Interval 1 days
Nile River
Bahar Yusef
Badraman
Dairutiah
Ibrahimia
##########
14,000 (fed)
30,000 (fed)
42,000 (fed)
##########
Abo Gabal
Irad Degaw
Sahelyia
24,000 (fed)
15,000 (fed)
Dirout Group of Regulators
El Kosia 20,000 fed 7.579 m3/s
Irad El Manarak 9,000 fed 3.411 m3/s
Assiut Regulator
1,565,000 (fed)
Ibrahimia Head Regulator
Nile River
W
P
Regulator
Weir
Gate for Branch Canal
Water Level (up)
Water Level (down)
Pump Station
Name Area Discharge
Name of Facility
Command Area (fed)
Plan of Distributed Water

Figure 5-1.7 Layout map of the target area (draft)

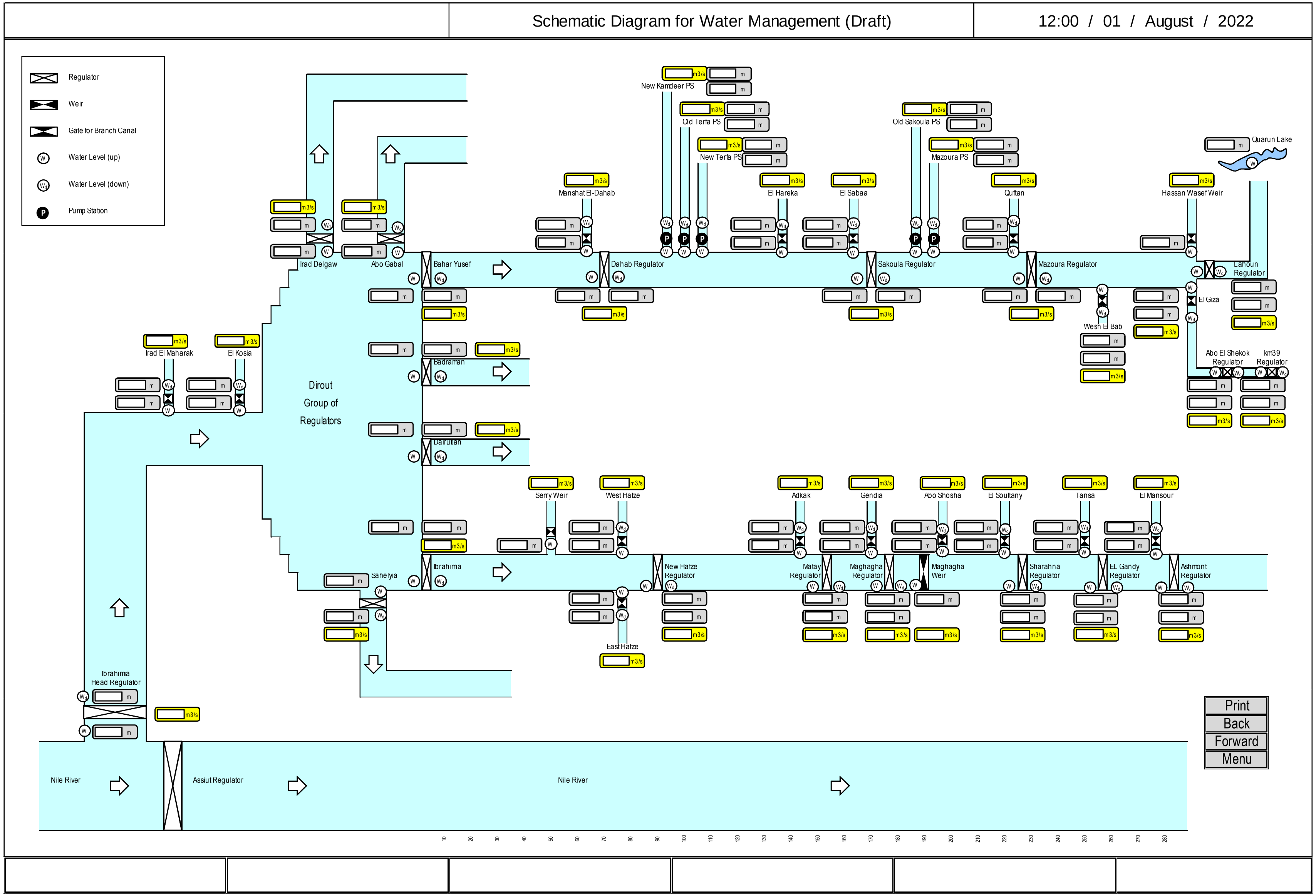


Figure 5-1.8 Layout of the monitored data at target area (draft)

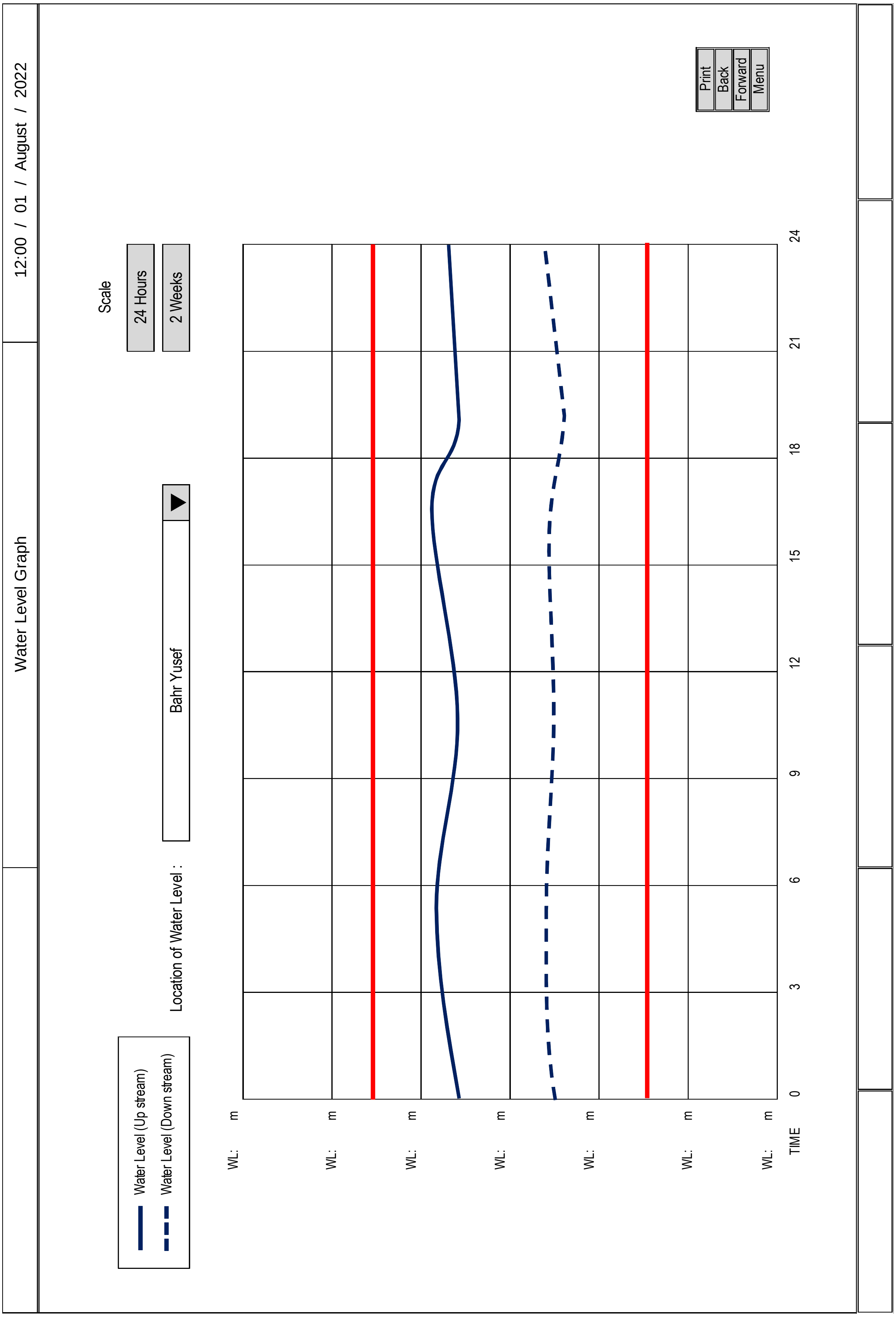
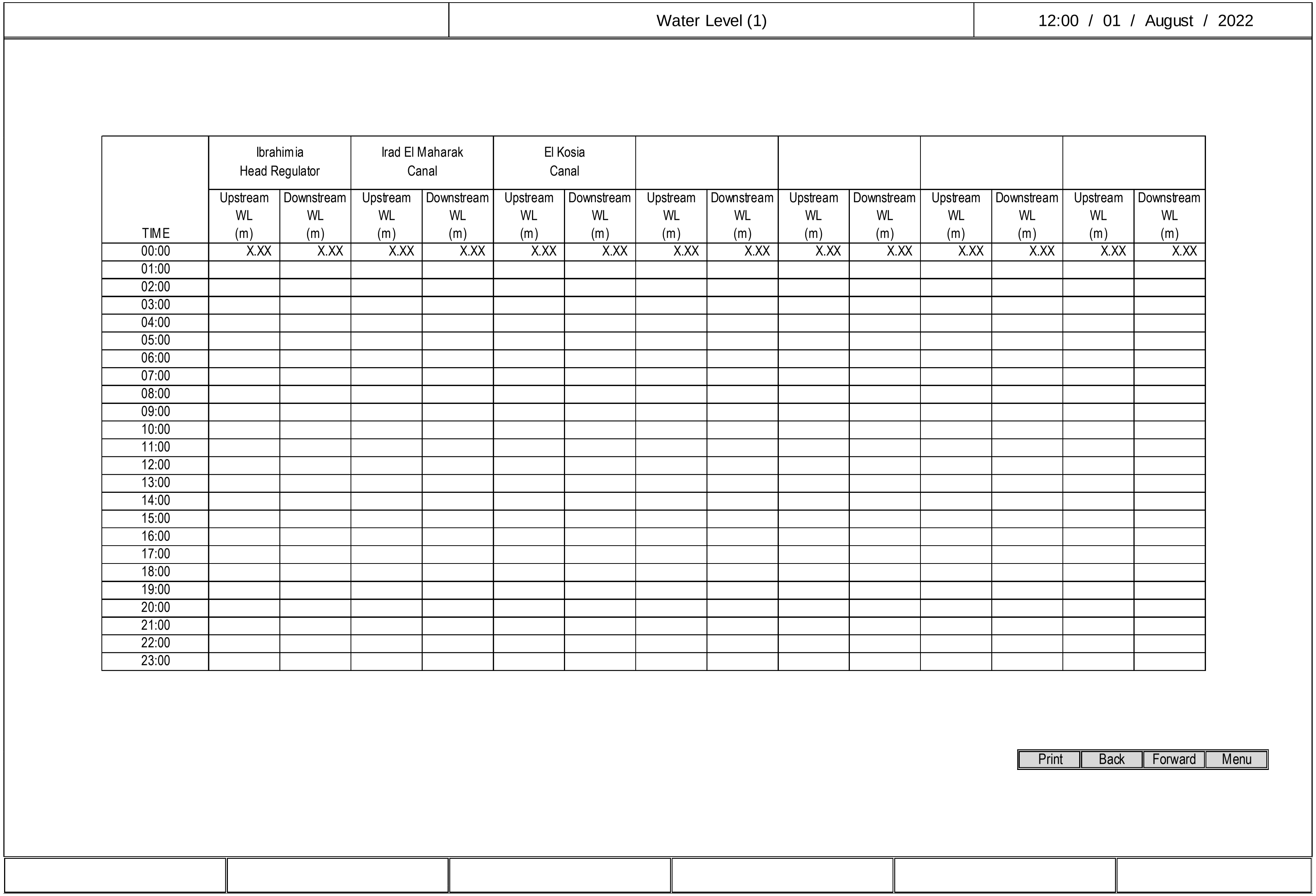


Figure 5-1.9 Output image of graph of water level data (draft)



TIME	Ibrahimia Head Regulator		Irad El Maharak Canal		El Kosia Canal									
	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)	Upstream WL (m)	Downstream WL (m)
00:00	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX
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22:00														
23:00														

Figure 5-1.10 Output image of table of water level data (draft)

Table 5-1.4 Example of crop consumptive water use

Season	Crop	Water Duties (CUM/fed)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter	Wheat	265.44	328.02	557.34	485.10	70.98						47.46	242.34
	Long berseem	247.80	352.80	541.80	663.60	550.20						231.60	252.00
	Sugar beet	258.32	335.83	615.35	932.06	1,195.49	603.60						135.51
	Legums	272.16	302.40	500.22	101.60							142.80	248.64
	Vegetables	117.60	67.20	71.40	58.80				29.40	210.00	394.80	373.80	285.60
	Other crops	420.00	399.00	273.00									146.00
	Short berseem	247.80	352.80									235.20	256.20
Summer	Rice					21.00	130.20	1,289.40	1,457.40	1,423.80	369.60		
	Maize					205.80	638.40	640.80	680.40	147.00			
	Sorghum					194.30	620.10	930.00	660.80	140.00			
	Oil crop					575.40	945.00	890.40	176.40				
	Vegetables			92.40	142.80	260.40	697.20	432.60	201.60	184.80	197.40	117.60	
	Other crops							147.00	520.80	609.00	537.60	474.60	113.40
Nile	Maize							252.00	663.60	751.80	529.20	163.40	
	Sorghum							241.30	650.20	740.00	515.10	110.20	
	Vegetables					21.00	100.80	260.40	403.20	344.40	277.00	197.40	
	Other crops			298.00	449.40	478.80	520.80	600.60	680.40	659.40	453.00		
Permanent	Sugar cane	195.30	294.00	428.40	516.60	716.10	768.60	859.32	950.46	894.60	690.06	541.80	312.48
	Cotton			127.68	390.60	664.02	806.40	915.18	429.66	207.60			
	Fruit trees	403.00	364.00	465.00	490.00	527.00	510.00	527.00	518.00	480.00	496.00	390.00	356.00

Source: MWRI (as for fruit trees, data of sprinkler in delta is used)

Table 5-1.5 Inspection items (water level sensor)

No	Outline	Scope of inspection works	Inspection interval				
			Everyday	one month	three month	six month	twelve month
1	Status of installation	Check the installation status of the sensors				○	
2	Confirmation of outdoor facilities and cleaning of protective pipe	Confirmation of the status of outdoor facilities such as water level sensor's protective pipe, pull box, conduit and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts. Remove sediments such as mud and sand accumulated in the lower part of the water level sensor's protective pipe and inside the pipe.			○		
3	Comparative test	Compare and check the level of staff gauge and water level displayed on the remote and master station. Confirm the water level by the sensor submersion test.					○
4	Confirmation of connection status	Check the connection status of connection cable, connector and terminal etc.			○		
5	Cleaning of sensor	Clean the inner and outer of the equipment body.				○	
6	Confirmation of documents	Confirm that the documents and drawings are organized and kept.					○

Table 5-1.6 Inspection items (solar panel)

No	Outline		Scope of inspection works	Inspection interval				
				Everyday	one month	three month	six month	twelve month
1	Confirmation of charging status		Check on remote station or master station that it is being charged every day				○	
2	Solar panel	Inspection of appearance	Confirmation of the status of outdoor facilities such as solar panel and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts.				○	
		Confirmation of connection cable	Confirmation of cable deterioration and cable laying status.				○	
		Sunshine condition	The surrounding environment at the installation direction of the solar panel. Confirm that there is no obstructing the sunlight for solar panel by tree growth etc.				○	
4	Confirmation of connection status		Check the connection status of connection cable, connector and terminal etc.				○	
5	Cleaning of solar panel		Clean the inner and outer of the solar panel					○
6	Confirmation of document		Confirm that the documents and drawings are organized and kept.					○

Table 5-1.7 Inspection items (measuring equipment)

No	Outline		Scope of inspection works	Inspection interval				
				Everyday	one month	three month	six month	twelve month
1	Measurement of Voltage		Measure (check) the circuit voltage etc. at the remote station of master station.				○	
2	Operation confirmation		Whether the water level sensor is correct or not, confirmed by the displayed present water level data through the monitoring device and the water level trend (operation log).				○	
3	Battery checking		Check the replacement cycle of the storage battery and replace the target one.					○
			Confirmation of the status of facilities such as battery and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Replacement of the target one.					○
			Check that the voltage etc. are normal. Replace targeted items.					○
4	Cable checking	Inspection of appearance	Confirmation of the status of outdoor facilities such as cables and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts.					○
		Confirmation of cable	Confirmation of cable deterioration and cable laying status.					○
5	Enclosure checking		Confirmation of the status of outdoor facilities such as enclosure and mounting parts with deformation, damage, abnormal rusting, corrosion and paint peeling etc. Confirmation of loosening and dropping of screws and bolts.					○
6	Confirmation of connection status		Check the connection status of connection cable, connector and terminal etc.					○
7	Cleaning of equipment		Clean the inner and outer of the equipment body and filter.					○
8	Confirmation of document		Confirm that the documents and drawings are organized and kept					○

Table 5-1.8 Inspection items (monitoring equipment)

No	Outline		Scope of inspection works	Inspection interval				
				Everyday	one month	three month	six month	twelve month
1	Server	Confirmation of voltage etc.	Check the power supply voltage etc. with the check terminal					○
		Replacement of battery	Check the replacement cycle of the backup battery and replace the target battery.					○
		Confirmation of CRT display	Check brightness and color etc and check that there is no abnormality status.					○
		Confirmation of hard disk	Check operating time and bad sector status					○
		Confirmation of function of black out and power supply recovery	Confirm that power failure detection, data save processing at power failure detection, etc. are normally performed by interlocking with the uninterruptible power supply.					○
			Confirm that automatic startup processing at power recovery is performed normally.					○
			Check file protection function, backup function, etc					○
		Operation check	Use the test program to check the operation status as a server.					○
		Confirmation of event log	Check the OS event log (system and application) and confirm that there are no logs showing symptoms or occurrence of hardware abnormality or OS abnormality.					○
		Confirmation of connection status	Confirmation of connection cable, connecter, connection status of terminals and loosening of plug-in.					○
		Cleaning of equipment	Clean the outer of the equipment body					○
			Confirmation and cleaning of keyboard and mouse etc.					○
			Cleaning of fun and filter					○
			Check the status of equipment installation.					○
2	System operation (confirmation of monitoring display)	Display of status of remote station	Confirm that the equipment status of the node (water level measurement data and detailed node information) is displayed.				○	
		Display of current water level	Confirmation of displaying the latest water level data				○	
		Display of water level trend	Confirmation of historical water level data				○	
		Display of historical record	Confirmation of display of historical event data				○	
		Data recording	Confirmation of recorded data				○	
3	Confirmation of document		Confirm that the documents and drawings are organized and kept					○

Volume Ⅲ CONSTRUCTION PLANNING & COST ESTIMATION

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1 Temporary Works

1-1 Outline of the project

The construction site is located in an urban area, and the national railway and the national road run on the east and west sides, respectively, of the construction site. Both the temporary work plan and the construction plan were formulated using the field survey, the existing condition survey, and the construction equipment and materials survey, and take the actual conditions around the site into consideration.

The project consists of the following two components.

(a) Construction of the NDGRs 140 m downstream from the existing DGRs.

(b) Improvement of the communications facilities pertaining to the construction of the water distribution system.

Components (a) and (b) are formulated based on the principle that (1) the DGR renovation plan and (2) improvement of the system environment to support daily water management policy are inseparable if the original capabilities of the existing dysfunctional DGRs are to be restored. RGBS is the main agency responsible for the execution of this project.

The two sub-projects consist of the following works.

Table 1-1.1 Outline of the project

Item	Structures
(1) New Dirout Group of Regulators	
(a) Construction of new regulators	Construction work on six regulators
(b) Installation of gates	
Bahr Yusef	W 6.0 m × H 6.55 m, total 4 vents
Ibrahimia	W 6.0 m × H 6.55 m, total 4 vents
Abo Gabal	W 2.0 m × H 2.40 m, total 4 vents
Badraman	W 2.0 m × H 2.65 m, total 2 vents
Diroutiah	W 2.0 m × H 2.35 m, total 3 vents
Sahelyia	W 2.0 m × H 1.90 m, total 2 vents
(c) Improvement of peripheral facilities	Construction of maintenance bridge Improvement of retaining walls
(d) Cofferdam works	Single and double cofferdams of steel sheet pile
(2) Integrated Water Management	
(a) Main canal gates management system (b) Branch canal intake management system (c) Establishment of integrated water management centre	Monitoring system installation work Monitoring system installation work Construction of centre building

The applied reference criteria and manual used in the study are:

1. *Manual for double steel sheet pile method*, Ministry of Land, Infrastructure, Transport and Tourism.
2. *Guidelines for temporary structures in road works*, Japan Road Association.

Figures 1-1.1, 1-1.2 and 1-1.3 show the drawings for the construction plan and the cross-sectional map of the two large regulators (new Bahr Yusef and Ibrahimia regulators).

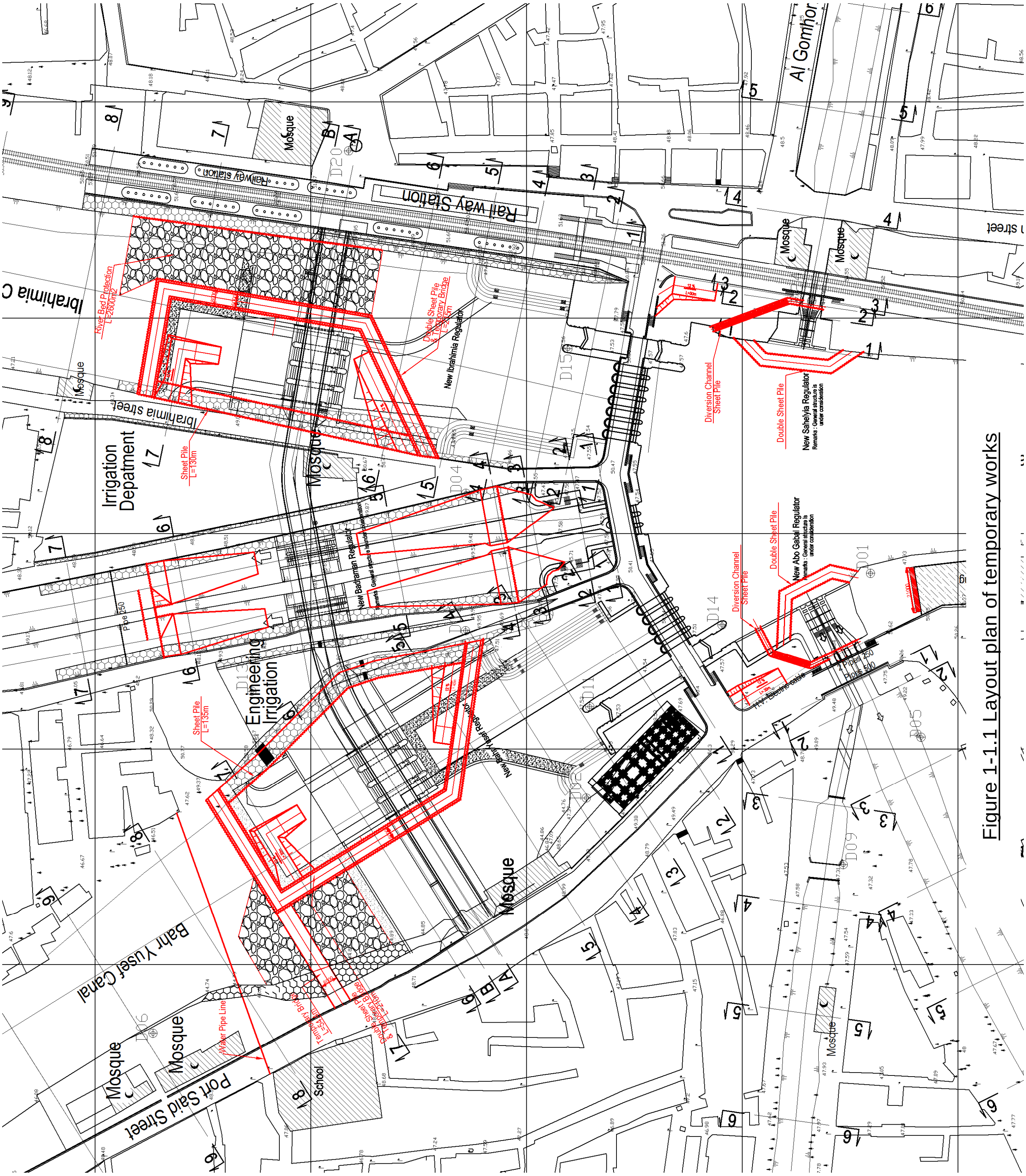


Figure 1-1.1 Layout plan of temporary works

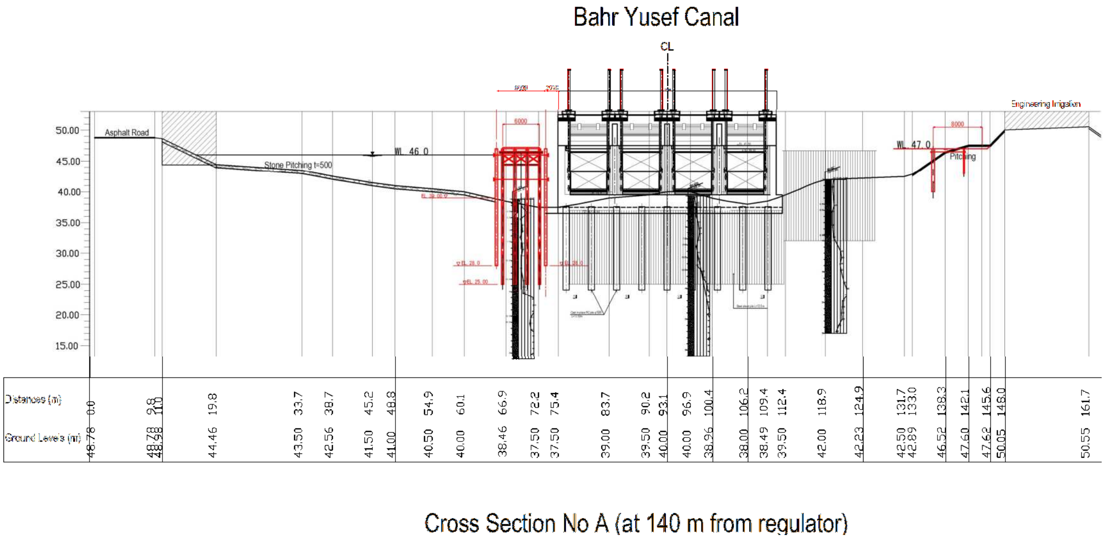


Figure 1-1.2 Cross section of the new Bahr Yusef regulator during temporary works

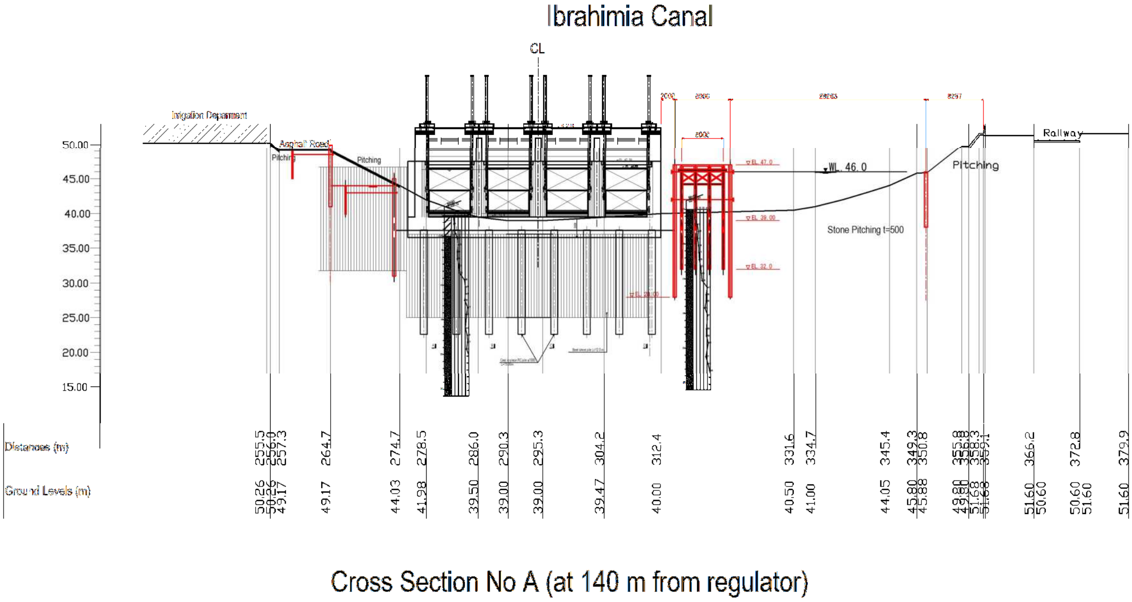


Figure 1-1.3 Cross section of the new Ibrahimia regulator during temporary works

1-2 Work conditions

(1) Construction Period

Due to the volume of work to be done, the planned construction period of the New Dirout Group of Regulators is 51 months.

Start of construction:	February 2018
Completion of construction:	April 2022

(2) Work Days

The work on the New Dirout Group of Regulators involves mainly earth works (excavation, embankment etc.) and concrete work. The work days are the number of days less the days no work is possible due to weather (temperature or rainfall etc.) and holidays. The weather is unlikely to influence the construction, because the temperature at the construction site is 3°C or higher throughout the year and rainfall is less than 1 mm; thus, the non-working coefficient is 1.35, which is the normal value for construction works.

Nonworking coefficient (1.35)
General works: 1.35
Working days per year: 270 days (365/1.35)
Working days per month: 270 days/12 months = 22.5 days
Working hours: 8:00~17:00 (9 hours): 8 working hours per day plus 1 rest hour.

(3) Soil Classifications

The soil classifications applied for the New Dirout Group of Regulators are as follows:

Table 1-2.1 Soil classification

Soil & Geology Classification	Soil Classification	Applicable name	After excavation
Top soil	Clay	—	Clay
River bed deposits	Sand (with gravel)	Sand (with gravel)	Sand (with gravel)
Purchased material	Sand and gravel	Sand and gravel	Sand and gravel

1-3 Construction plan

(1) Temporary bridge

The DGR crosses the upstream Ibrahimia canal and is used as the bridge for the local main road as there are few bridges crossing the Ibrahimia canal in this area. Heavy trucks weighing more than 20 tonnes are prohibited from passing over the bridge; therefore, a temporary bridge strong enough to withstand heavy construction vehicles is needed. A temporary bridge cannot be built on the Ibrahimia canal because the railway goes along the right bank of the Ibrahimia canal.

The conditions for a temporary bridge over the Bahr Yusef canal are discussed below.

(a) Location

The location of the temporary bridge will be selected in accordance with the following conditions:

1) Land acquisition will not upset the lives of residents.
2) Location is near the construction site, without obstacles preventing access to the construction yards.

Candidate sites for the temporary bridge are proposed upstream and downstream of the Bahr Yusef regulator. The upstream site is not as wide as the downstream site, and is too close to the DGRs. Therefore, the downstream site is better for the construction of the temporary bridge. In order to ensure road access for construction vehicles, the temporary bridge will be designed to extend over the entire width of the Bahr Yusef canal.

(b) Length

The temporary bridge will be 100 m long to span the Bahr Yusef canal, as construction vehicles are prohibited from crossing the DGR bridge. The location of the temporary bridge was moved slightly upstream (closer to the downstream end of the double cofferdam) to avoid a water pipe discovered in the original location during the field survey.

(c) Design load

The design load of the temporary bridge should be more than 20 tonnes, which is the general traffic load of construction vehicles, machinery and cars. The maximum design load at the time of the installation of the gate is assessed as the weight of a truck crane, which can carry a load of up to 80 tonnes.

(d) Width

The construction of the temporary bridge will begin on the left side of the canal, and the H-steel bridge piers will be driven into the pier at 6 m intervals using heavy machinery. The driver machine will drive in the H-steels moving along the temporary bridge from the left side of the canal to the right side. The width of the temporary bridge is designed to be 8 m.

Since the temporary bridge will also be used by construction vehicles, the width of the temporary bridge will be 8 m to allow for two-way traffic.

(e) Span length

The pier spacing for the temporary bridge is planned to be 6 m, as the pier interval is usually set between 5 m and 6 m.

(2) Temporary cofferdam

The steel double sheet pile method, which is widely used in Japanese engineering projects, shall be applied on account of its high water cut-off performance- and smaller working area. Because the construction site is situated in the centre of Dirout City, vibration and noise must be kept to a minimum.

The reasons for use of the steel double sheet pile method are as follows:

1) The construction site is in a canal with flowing surface water, hence a high level of water-tightness is required to keep the worksite dry.

2) A temporary bypass canal cannot be used during construction because of the urban location of the works.

3) A multiple-stage diversion method will be adopted to ensure that water distribution through the canals is not stopped during the construction of the NDGRs. The work area in the canals should be kept as small as possible, and the steel double sheet pile method can help minimize

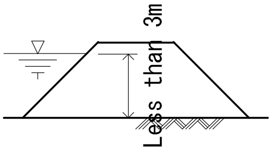
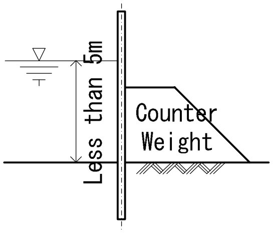
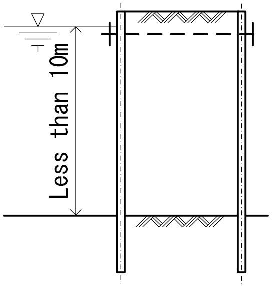
the size of the work area.

4) The steel double sheet pile is considered appropriate for the water depth.

There are three main cofferdam methods for the construction of temporary works: (1) the fill materials embankment method, (2) the single steel sheet pile method, and (3) the steel double sheet pile method. The method is chosen according to the water depth of the worksite, in this case about 7 m.

The maximum water depths for each method are shown in Table 1-3.1. The fill materials embankment method is suited to depths of around 3 m; the single steel sheet pile method to depths of around 5 m: and the steel double sheet pile method to depths of around 10 m. Therefore, the steel double sheet pile method will be adopted for the design water depth of 7 m.

Table 1-3.1 Cofferdam method

Method	Embankment	Single sheet pile	Steel sheet pile
Overview			
Maximum Water Depth	Up to 3 m	Up to 5 m	Up to 10 m
Design Water Depth	7 m	7 m	7 m
Assessment	NG (7 m > 3 m) Design depth is more than maximum water depth	NG (7 m > 5 m) Design depth is more than maximum water depth	OK (7 m < 10 m) Design depth is less than maximum water depth

Steel double sheet pile cofferdams have already been successfully used in the Dahab and the Sakoula regulators, which are on a similar scale to the NDGRs. The work process is as follows:

1) Construction of temporary bridge substructure (H-steel bearing piles)
2) Reinforcement work (strut or brace)
3) Construction of temporary bridge superstructure (W=6 m)
4) Steel sheet piling
5) Reinforcement work (waling)
6) Tie rod and waling work
7) Ground improvement and banking
8) Removal of temporary bridge
9) Filling embankment

The use of a hydraulic piledriver and electric water jet to drive the steel sheet piling is planned because the N value of the foundation layer is higher than 20.

The filling soil used in the steel double sheet pile will be brought from the borrow site located

19 km from the construction site. The filling soil is for the banking of the regulator and should be removed immediately after the removal of the first cofferdam, stored temporarily, and then moved to be used as filling soil for another cofferdam.

1-4 Preparation plan

(1) Transport and packing plan

- **Transport from Japan and third countries**

The transportation route is from a port in Japan through the Indian Ocean and the Suez Canal to Alexandria. Packing and customs clearance in Japan will take two weeks, and then it will take about one month to reach Alexandria Port. It will take another two weeks to unload and pass through customs at Alexandria Port, and two days to travel inland from Alexandria to the Dirout site by truck or trailer.

- **Domestic transport**

The construction materials and machinery from Cairo City, Minia city and surrounding suburbs will be transported on trucks or trailers. The large construction materials (steel sheet piles, H steel, gate equipment, large machinery, etc.) will be transported on large trucks and trailers, and will be brought into the site from the left bank.

Preparation works are planned at the start of construction, during the construction period, and during the cleaning-up stage after completion of the works.

(2) Preparation Work

The preparation works planned include preparation at the start of construction and during construction, clearing-up and clean-up after the completion of the works.

(3) Security

Security precautions such as the erection of a fence around the construction site and the hiring of guards are planned. The fence around the site will be of wooden stakes (l=2.5 m) and barbed wire (B=1.25 m).

Table 1-4.1 Assignment of security guards

Traffic control	Temporary road	2 persons × 20 months
Security guards	Temporary yard	Day and night shift 2 persons × 3 locations × 21 months
	Site office	Day and night shift 2 persons × 21 months

(4) Temporary yards

The temporary yards will accommodate a workshop (rebar/formwork), a warehouse (for general materials and cement), a testing laboratory, a concrete plant and a yard for the storage and assembly of steel materials and gate equipment. A batching plant and temporary storage yard will also be necessary near the construction site. The required area of the temporary yards as follows.

Batching plant: 2,500 m^2
Material stockyard: 4,000 m^2 (sheet piles, foundation piles, etc.)
Material stockyard: 2,000 m^2 (backfill materials, etc.)
Workshop yard: 1,000 m^2 (reinforcing bars, formwork, etc.)
Heavy equipment yard: 2,000 m^2
Office and parking: 500 m^2
Total 12,000 m^2

It is planned to locate the temporary yards close to the construction site but if there is not enough space other prospective sites will be prepared in the area around the site.

Table 1-4.2 Temporary yards near the construction site

No.	Temporary Yard	Area (m^2)	Remarks
①	Irrigation Department	2300	Batching plant
②	Irrigation Department	700	Administration office
③	Irrigation Engineering	1700	
④	Irrigation Department	1100	
⑤	Irrigation Department	600	Construction road
⑥	Bahr Yusef left bank	450	Materials stock yard
⑦	〃	350	Materials stock yard
⑧	〃	600	Former site of Mosque
⑨	〃	450	Materials stock yard
⑩	Bahr Yusef right bank	500	Materials stock yard
	Total	8,570	

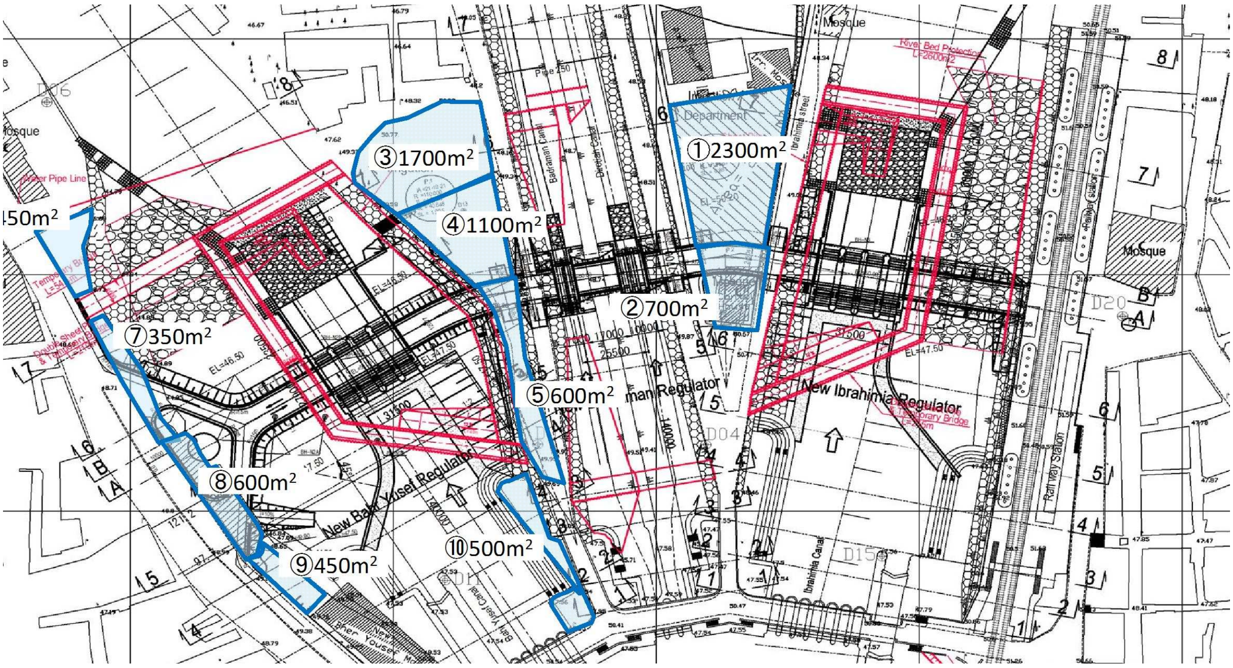


Figure 1-4.1 Location of temporary yards

Table 1-4.3 Prospective temporary yards around the site

Temporary yard	Location	Distance (km)	Area (m^2)	Condition	Remarks
1	Near Cotton Factory	0.5	15,000	Residential area	
2	Beside ring road	3	5,000	Field	
3	Beside ring road	4	4,000	Field	2 areas
4	Beside Badraman Canal	1	4,000	Field	
5	Beside Badraman Canal	2	4,000	Field	

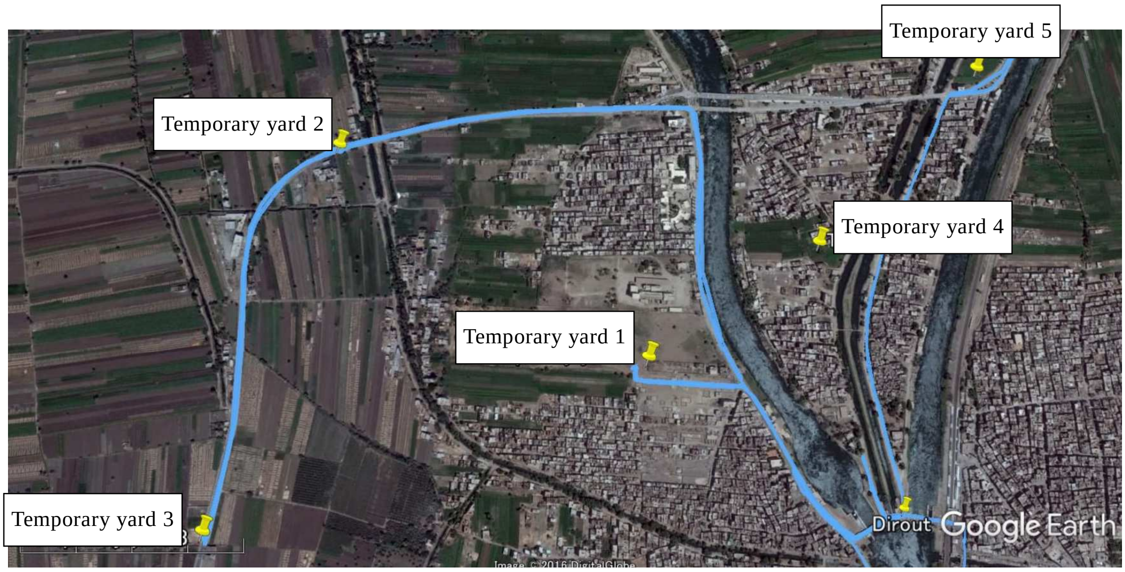


Figure 1-4.2 Prospective temporary yards around the site

(5) Temporary facilities

The temporary facilities will be built in the temporary yards as follows:

Table 1-4.4 Temporary facilities

Temporary Facility	Purpose	Area
Site office	Consultant and contractor office for construction management	About 200 m^2
Work shop	Preparation of reinforcing bars and formwork, 25 persons	About 200 m^2
Warehouse	Storage of tools, small machinery, materials and mechanical and electrical equipment	About 200 m^2
Cement warehouse	Storage of cement, volume 100 tonnes (maximum concrete casting volume: 250 m^3/day)	40 m^2
Laboratory	Testing of concrete and soil	40 m^2
Toilet / Shower room	For workers	3 m^2
Break room	For workers	40 m^2
Workers' camp	Accommodation for skilled construction labourers employed away from home	About 200 m^2

(6) Power plan

During the construction period, electric power can be provided from an electric power source (150 kVA) beside the main road to the construction site. However, as power outages occur frequently in the area, electric generators will be kept on standby at the site. A major construction accident could occur if the power were to stop in the middle of steel sheet pile driving work or deep well work where power is needed for short concentrated periods.

Electricity will be needed constantly over the long term in the temporary yards, for tools, lighting, the workers' camp, and the concrete plant. A backup power generator (1 unit, 80 kVa) will be installed.

(7) Construction management

(a) Materials

The office equipment used to prepare management reports on the quality control and volume of earth work, foundation work, concrete work, pavement work, mechanical and electrical work, etc., and survey, drafting and photographic equipment etc., will be appropriated.

Table 1-4.5 Construction management equipment

Item	Equipment	Quantity
Survey	Auto level	2
	Total station	1
Photo	Camera (including compact camera 1)	2
Office	Personal computer	2
	Copy machine	2

(b) Quality control

Quality control will be carried out for the earth work, concrete work, pavement work, and the mechanic and electrical work.

Table 1-4.6 Quality control

Work	Control item	Method	Measurement
Basement	Soil condition Width, Height Bearing capacity	Visual Measurement Flat-plate load test	Per main section Per main section Once per main structure
Banking	Compaction	Site density	Every 400 m^2
Concrete	Aggregate Cement Fresh concrete Strength	Grain size test Physical / chemical test Slump / air / chloride / alkali aggregate reaction test Compression strength test	Every 3,000 m^3 Every 1,000 tonnes Each casting Each cast section or Every 200 m^3
Reinforcing bar	Strength bar arrangement	Tension strength test Check of condition	Every 200 tonnes Each cast section
Completed structure	Completed dimensions	Dimensional measurement	Each main member
Mechanical equipment	Installation precision Performance	Installation position measurement Load operation test	All equipment All equipment at test Operation

(8) Building and maintenance

(a) Site office

The plan is to build the site offices of the consultants and the contractor in the temporary yard and to lease a liaison office in Cairo City. This is because the construction site in Dirout is 500 km from Cairo City, which is well situated to relay the procurement and transportation of construction equipment between Alexandria and Dirout.

(b) Lodging

A rented house near the temporary yard will house the Japanese engineers, and the skilled labourers and workers from Cairo or elsewhere will reside in a specially-built concrete block building with wood trusses and galvanized iron roofing.

1-5 Procurement plan

(1) Workforce

(a) Engineers and labourers

Ordinary workers, security guards and clerical staff can be procured from Dirout City and towns and villages close to the construction site.

Other employees, such as engineers, drivers, skilled workers such as carpenters, rodmen and plasterers shall also be hired. Shortages of skilled and short-term labour during the construction peak period will be hired from Cairo.

(b) Labour benefits

In addition to severance pay, social insurance and bonuses, government offices and private companies in Egypt must pay workers who cannot commute from home overtime pay, remote location allowance, commuting allowance and accommodation allowance. Thus, all these benefits will be paid with the exclusion of the accommodation allowance, as labourer accommodation in the temporary yard is already planned.

As ordinary workers, security guards, and clerical staff will be hired from Minia City and towns and villages close to the construction site, a commuting allowance to cover transport from their residence will be paid but there are no plans to pay the remote location allowance.

The workers to be paid daily and the workers to be paid monthly under this plan are as follows:

Table 1-5.1 Personnel expenses

	Work	Overtime	Remote location	Commuting	Remark
Paid daily	Manager	○	○	−	
	Special worker	○	○	−	
	Ordinary worker	○	−	○	Hired from local area
	Scaffold worker	○	○	−	
	Steel worker	○	○	−	
	Special driver	○	○	−	
	Driver	○	○	−	
	Carpenter	○	○	−	
	Masonry worker	○	○	−	
	Painter	○	○	−	
	Welder	○	○	−	
	Electrician	○	○	−	
	Mechanic	○	○	−	
	Plumber	○	○	−	
	Security guard	○	−	○	Hired from local area
Paid monthly	Civil engineer A	○	○	−	15 years of experience or more
	Civil engineer B	○	○	−	10 years of experience or more
	Surveyor	○	○	−	
	Assistant surveyor	○	○	−	
	CAD operator	○	○	−	
	Accountant	○	○	−	
	Office worker	○	−	○	Hired from local area
	Driver	○	○	−	
	Mechanical engineer	○	○	−	
	Electrical engineer	○	○	−	

Standard working hours in Egypt is 7 hours, but an 8-hour workday (9 hours less one rest hour) is planned for this project; hence one hour of overtime should be paid. Overtime pay in the case of work in excess of 7 hours/ weekday in Egypt is as follows:

3 hours' overtime	135%
Night shift work	150%
Holidays and Fridays	200%

Severance pay shall be paid only to those local employees who are employed by the Japanese contractor and are paid on a monthly basis. The normal rate for severance payment in Egypt is 25% of the total amount paid.

(2) Construction materials

(a) General Construction Materials

A stable supply of most of the construction materials such as cement, reinforcing bars, wood, steel products, joinery and ventilation and lighting equipment can be procured in Egypt and transported to the site from Cairo. The reinforcing bars are available only from a factory in Alexandria City.

(b) Filling materials, aggregate and stone materials

Borrow sites for the filling material and quarry sites for the aggregate and stone materials will be situated near the construction site.

Filling materials: The borrow site at Dirout on the desert road, about 19 km from the construction site.

Rubble, masonry: The quarry site at Assiut, about 60 km from the construction site.

Coarse aggregate: The quarry site at Dirout, about 30 km from the construction site.

Fine aggregate: The quarry site at Minia about 100 km from the construction site.

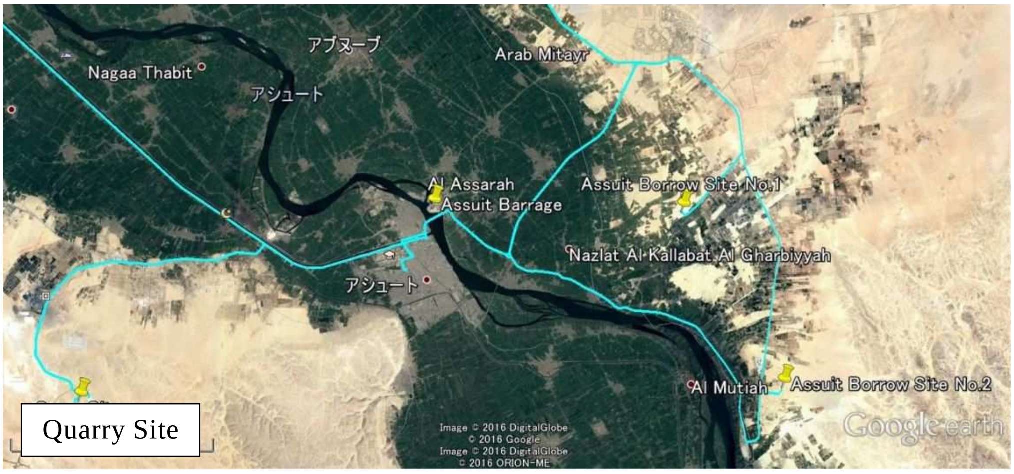


Figure 1-5.1 Quarry sites in Assiut

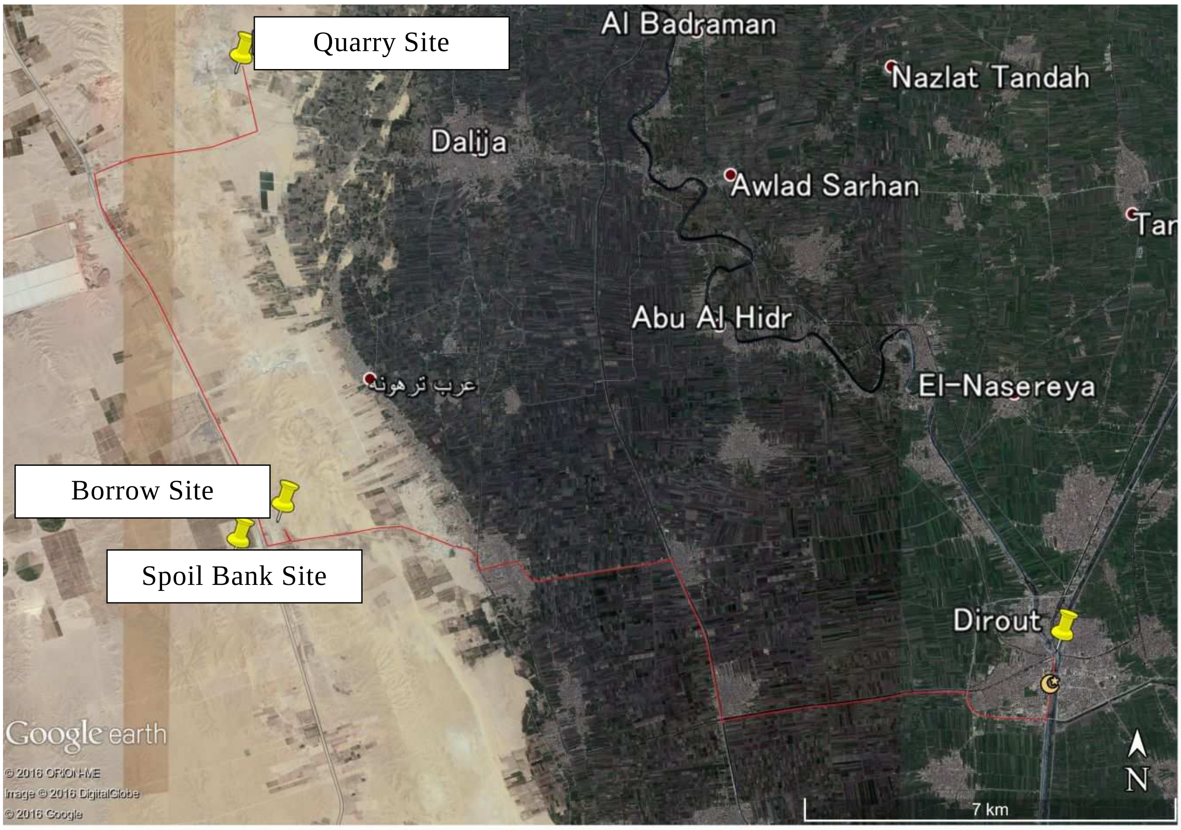


Figure 1-5.2 Locations of borrow site, quarry site and spoil bank site near Dirout

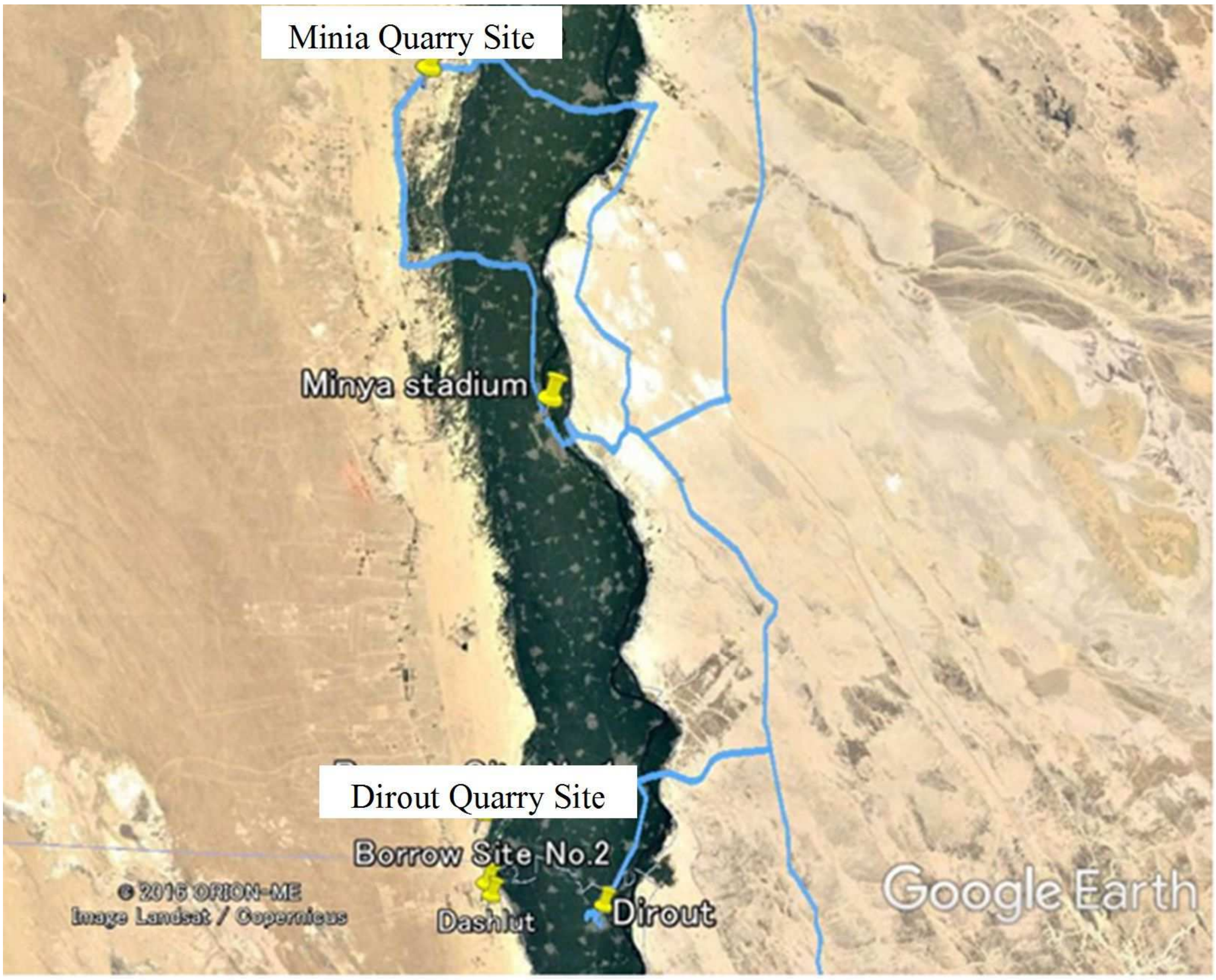


Figure 1-5.3 Location of quarry sites in Minia and Dirout

- Quarry site

The quarry site for coarse aggregate is located 30 km from the NDGRs. This quarry site is managed by a private company and has alternate layers of sand and gravel. The company excavates directly at the exposed sand and gravel layer, and screens the excavated materials by machine.

The quarry site for fine aggregate is located at Minia.

- Borrow site

The borrow site is located near the junction of the desert road. Backfill material can be provided from the site. The distance from the NDGR is approximately 19 km. The road is wide enough for a dump truck to pass along. The geological conditions are the same as those at the quarry site, with alternate layers of sand and gravel.

- Spoil bank site

The spoil bank site is located near the junction of the desert road and the borrow site.

(c) Steel materials

H-steel of up to H-250 mm can be procured from the local market, whereas H-steel of H-300 mm and more must be imported. This is because H-300 mm H-steel is not produced in Egypt but is imported through an import agent. It is therefore difficult to ensure the timely procurement of sufficient quantities of the imported material (H-steel of 300 mm or more).

Therefore, it is planned to procure H-steel of up to 250 mm locally and to procure larger size H-steel materials from Japan.

(d) Scaffolding and formwork

Most of the local construction companies use wooden scaffolding and loose-plank formwork materials, so wooden materials can be procured. However, the local plywood formwork is of low quality and cannot be used repeatedly, and the low mould accuracy reduces the quality of the finished concrete structure, making it of lower quality than that of the regulators of Lahoun, Mazoura, and Sakoula.

Thus, plywood formwork, steel scaffolding and support materials are to be procured from Japan, while the wooden scaffolding, support materials and square timber will be procured locally.

(e) Special materials

Special materials such as steel sheet piles, large steel materials and plywood formwork material are to be procured from Japan to alleviate anxiety regarding delivery and to ensure sufficient quantities. The high-tension tie rods, bridge bearings and expansion equipment will be procured from Japan, because quality is of particular importance for these special materials.

(f) Gate materials

The gates to be installed in the weirs are of the double leaf gate type. These gate sets are to be procured from Japan in consideration of the excellent production technology, track record, and quality.

Table 1-5.2 Procurement of construction materials

Item	Equipment	Local	Japan	Third country	Remarks
Construction materials	H-steel	○			100~250 mm
	H-steel		○		300 mm or more cannot be procured locally
	Steel sheet pile			○	Comparison of procurement cost
	Deck plate		○		Cannot be procured locally
	Barbed wire	○			
	Deformed bar	○			
	High-tension tie rod		○		Cannot be procured locally
	Cement	○			
	Fine aggregate	○			
	Coarse aggregate	○			
	Water reducing agent	○			
	Banking soil	○			
	Rubble, masonry	○			
	Crushed stone	○			
	Square timber	○			
	Plywood formwork	○			Cannot be procured locally
	Steel scaffolding support	○			Cannot be procured locally
	Straight asphalt	○			
	Bridge bearing stretcher		○		Cannot be procured locally
	Step/ bridge railing	○			
	Gasoline, diesel oil	○			
	Cement board	○			
	Water stop	○			
	High voltage incoming panel	○			
Equipment and Facilities	Gate machinery		○		See “Gate materials” above.
	Gate distribution/ control equipment		○		See “Gate materials” above.

(3) Construction machinery

(a) General purpose machinery

Most general-purpose machinery is owned by the local construction companies. It is also possible to rent from local leasing companies. General-purpose machinery includes: backhoe, bulldozer, truck, trailer, truck with crane, crawler crane, rough terrain crane, truck crane, wheel loader, tire roller, vibration roller, mixer truck, rebar processing machine, emergency power generator, etc.

(b) Special machines

The steel sheet pile drivers (vibro-hammer and water jet) and the soil improvement machine will be brought from Japan, as issues relating to the site soil mean that special technologies and operating skills are needed.

(c) Concrete plant

A concrete plant will be installed to produce concrete. Although construction companies and ready mix concrete companies in Egypt own concrete batchers, they are not rented out. The concrete batching plant will be procured from Japan and its rent accounted for, because the concrete batching plant affects the concrete quality and the construction period. It is necessary to arrange immediate procurement once the construction contracts are secured, as the installation of the plant and the concrete mixing test will take time. The concrete plant can be procured through a local agency.

Table 1-5.3 Procurement of construction machines

Purpose	Machine	Local	Japan	Remarks
Construction Machine	Bulldozer (15 t)	○		
	Backhoe (0.8 m^3)	○		
	Dump truck (10 t)	○		
	Truck with crane (4 t/2.9 t)	○		
	Truck (11t), Trailer (20 t)	○		
	Crawler crane (50 t),	○		
	Rough terrain crane (25 t)	○		
	Truck crane (50 t)	○		
	Wheel loader (2.1 m^3)	○		
	Tire roller (8-20 t)	○		
	Vibration roller (10 t)	○		
	Vibration hammer (hydraulic)		○	Procurement must be done in a short time, and it is difficult for Japanese engineers to operate the Egyptian-made machinery.
	Water jet (14.7 MPa, 325 l/min)		○	Procurement must be done in a short time, and it is difficult for Japanese engineers to operate the Egyptian-made machinery.
	Concrete plant (30 m^3/hr)	○		
	Mixer truck (4.4 m^3)	○		
	Generator (75 kVA)	○		
	Generator (200 kVA)		○	To be used for the sheet pile driving in the early construction work; procurement must be done in a short time, and it is difficult to obtain a large generator in Egypt.

2. Construction of the NDGRs and Water Management Facilities

In the construction of the New Dirout Group of Regulators, the construction of Bahr Yusef regulator on the downstream side will begin first and next, the construction of Ibrahimia regulator will start. The construction of the other regulators, Badraman and Diroutiah, and on the upstream side, Abo Gabal and Sahelyia, will be performed in parallel with the construction of Bahr Yusef and Ibrahimia.

The construction flow of Bahr Yusef, Ibrahimia and the other regulators is as follows:

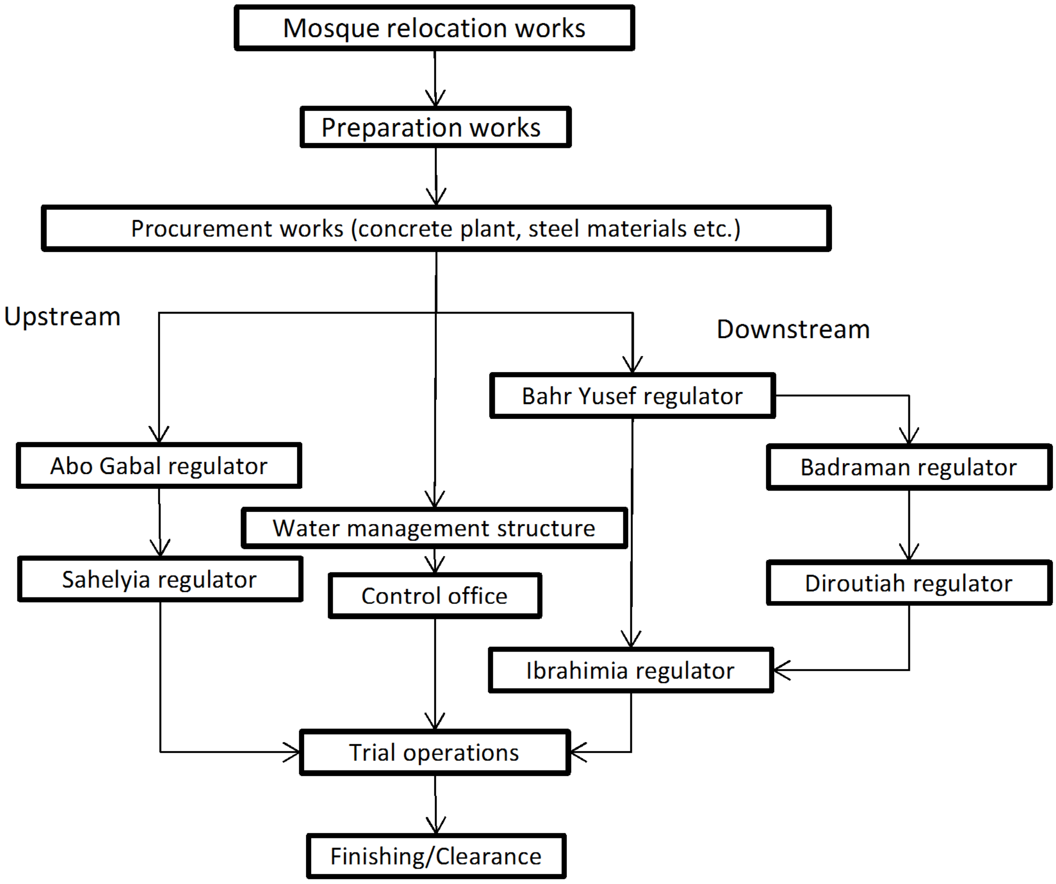


Figure 2-1.1 Regulator construction flow

The construction will start after the relocation of the mosque is completed by the Egypt side.

Preparation work → Temporary bridge → Double sheet coffer dam → Removal of existing facilities, Excavation inside site → Foundation piles and waterstop sheet piles → Construction of regulator structure → Installation of gates and trial operation → Removal of double sheet piles and switching diversion → Revetment work and appurtenant work (road works and electrical work) → Integrated trial operation/Operation training → Finishing/Clearing

The manufacture and transport of the gates, machinery and electrical equipment, the building work and the revetment work proceed in parallel with the construction of the structures and the installation and trial operation of the gates.

2-1 Construction of Bahr Yusef Regulator

The construction of the Bahr Yusef regulator begins after the relocation and demolition of the mosque.

(1) Preparation work

In the preparation work, preparations for the construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Temporary Bridge

The temporary bridge for the Bahr Yusef regulator is constructed on the downstream side of the regulator and connects the road on the left bank and the double sheet coffer dam. The temporary bridge is 43 m long and 8 m wide. The temporary bridge is made of steel and the construction work is divided into superstructure and substructure. The bridge piers are constructed first as the substructure and the superstructure is constructed.

(a) Superstructure

① Installation work	Weight of steel: 48.8 tons, crawler crane with 50 tons tonne lift capacity
② Deck plate work	Area: 336.0 m^2, crawler crane with 50 tons lift capacity
③ Handrail installation	Length: 86 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 9.3 m

Machine:	Maximum N value	N max < 50
	Driving length	9.3 m < 25 m (H350 steel)
	Extraction length	9.3 m < 25 m Hydraulic vibratory hammer

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer)

③ Installation of pier piles Weight of steel: 92.9 tons, crawler crane with 50 tons lift capacity

(3) Temporary Cradle

After the construction of the temporary bridge, the temporary cradle (width 6 m) is constructed. The sheet piles of the double sheet coffer dam are driven in from the temporary cradle. The temporary cradle is constructed first together with the driving in of the sheet piles. The temporary cradle is 210 m long and 6 m wide. The temporary cradle is made of steel and the construction work is divided into superstructure and substructure. The cradle piers are constructed first as the substructure and the superstructure is constructed.

(a) Superstructure

①	Installation work	Weight of steel: 179.8 tons, crawler crane with 50 tons lift capacity
②	Deck plate work	Area: 1,260 $m^{2,}$ crawler crane with 50 tons lift capacity
③	Handrail installation	Length: 420 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 9.3 m

Machine:	Maximum N value	N max < 50
	Driving length	9.3 m < 25 m (H400 steel)
	Extraction length	9.3 m < 25 m Hydraulic vibratory hammer

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 20 piles

② Installation of pier piles Weight of steel: 510.1 tons, crawler crane with 50 tons lift capacity

(4) Double Sheet Coffer Dam

The installation of the double sheet coffer dam is performed together with the temporary cradle work. Driving and extraction of the sheet piles are carried out by hydraulic vibratory hammer.

Sheet pile driving work

Driving length: 11 m

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

Connection of the sheet piles, PU28+1 (equivalent of Type IVw), is performed on the temporary cradle. The number of piles installed per day is 20 at less than 12 m in length (including the connection work).

(5) Double Sheet Coffer Dam Embankment Work and Removal of Temporary Cradle

After the installation of the double sheet coffer dam, the embankment is constructed and the temporary cradle is removed. The embankment volume is 14,280 m^3 and the transport distance is 19 km from the borrow site. The combination of loading and transport is backhoe loading 1.4 m^3 + 10 t dump truck.

The double sheet coffer dam embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(6) Demolition of Slope on Right Bank

The demolition and removal of the slope on the right bank are carried out by backhoe and the generated rubble is loaded by backhoe and transported by dump truck. The rubble is reused for temporary riverbed protection work.

(7) Sheet Pile Revetment Work on Right Bank

The sheet pile revetment is constructed on the right bank and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 4 m, H-250 2.25 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile PU28+1 (equivalent to Type IVw): 244 piles, driving length: 4 m)

Sheet pile PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 38 at less than 4 m in length.

③ Driving work (H-250 steel pile: 83 piles, driving length: 2.25 m)

Driving work: the number of piles installed per day is 48 at less than 4 m in length.

(8) Drainage Work

Drainage of the percolation from the foundation surface of the double steel sheet piles is conducted using the pump drain method and well point method, both separately and in combination. The construction site of the double steel sheet piles is surrounded by canal water and it is therefore necessary to select a drainage method that ensures the smooth progress of construction work, as the foundation surface of the excavation is highly permeable.

As the foundation conditions are such that there are thick geological layers with high permeability (silty clay and sand etc.), the combination of pump drain and well point methods is selected for the drainage work at the site. It is necessary to check the turbidity of the drainage water to prevent piping.

① Installation and removal of well points (length 360 m, interval 3 m, 120 well points)

② Installation and removal of well-point pumps (2 pumps, 2 spare pumps)

(9) Excavation Work and Embankment Work for Temporary Road

During the enlargement of the cross section of the canal by the installation of double steel sheet piles, underwater excavation is performed by backhoe (0.8 m^3) to a water depth of 6 m. Beyond 6 m, excavation is performed by clamshell. The embankment work uses the sand and gravel soil from the borrow pit and compacts it by vibrating roller.

It is difficult to obtain clay materials, because all the borrow sites around the site contain sand. The sand is embanked by sprinkling with water to ensure the strength of the embankment. The borrow site is located 19 km from the construction site near the spoil bank site.

① Excavation

・In double sheet coffer dam

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Riverbed area

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of temporary road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(10) Bed Protection Work

The bed protection and riprap works are planned under dry conditions before removing the double steel sheet piles. However, in the riprap work on the downstream side, which is outside the double steel sheet piles, the rock material will be cast into the water during the removal of the double steel sheet piles. The riprap material will be brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

Spreading of the riprap material is carried out by 21 tons bulldozer.

(11) Foundation Pile Work

Cast-in-place concrete piles are planned for the foundation of the regulator and the bored pile method is applied as the construction method. Excavation is carried out by earth auger and bentonite is used to secure the walls of the hole. The boring machine is a 42 tons crawler crane and the construction capacity is 3 piles per day.

(12) Waterstop Sheet Piles

The waterstop sheet piles are driven in by hydraulic vibratory hammer

Driving work: Driving length: sheet pile 4.5 m, 6 m, 12 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	4.5 m, 6 m, 12 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(13) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method
2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3/day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during concrete casting of the weir apron and the bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate is a long structure on the upstream side with a length of 27.9 m and on the downstream side with a length of 23.5 m. The total volume of concrete is 6,065 m^3.

(d) Basic Conditions

① Specifications of concrete

Concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

④ Casting method

The casting is done by 50 tons crane and the placement volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

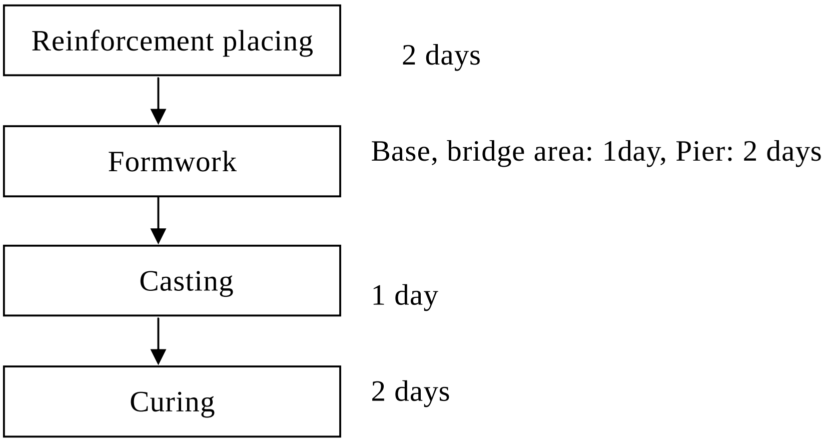
The casting schedule is decided based on the following conditions:

- The maximum volume of concrete placement is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the concrete casting is divided into 5 parts.
  - Base of gates on upstream side
  - Piers of gates on upstream side
  - Bridge area of gates on upstream side
  - Base of apron on downstream side
  - Wall of apron on downstream side

② Casting capacity

The volume of concrete per block is approximately 200 m^3 and the casting capacity including preparations is as follows:

Casting: one day including preparations
Demoulding: four days for cross section formwork



The workable days are considered except the curing days.

No. of days per cycle for casting (except curing) =2+1+1 = 4 days (base, bridge area)
=2+2+1 = 5 days (pier area)

After completion of the casting at the pier, work starts on the next block and the number of curing days is decided as 2 days.

The casting interval is normally a cycle of 5+2=7 days.

(14) Embankment on Right Side

The embankment on the right side is constructed after completion of the concrete work for the regulator. The volume of the embankment on the right side is 7,200 m^3 by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(15) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are conducted.

(16) Double Sheet Coffer Dam Excavation and Embankment on Left Bank

The soil for the double sheet coffer dam is excavated and transported, and the embankment on the left bank is constructed.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on left bank

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(17) Removal of Double Sheet Coffer Dam

The double sheet coffer dam is removed by hydraulic vibratory hammer.

① Machine

Extraction length: 11m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Extraction length 11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Extraction work (outside: 400 piles, length 11 m, inside: 350 piles, length 10 m)

The number of extracted piles per day is 50 at less than 12 m in length.

(18) Sheet Pile Revetment Work

The sheet pile revetment work is performed by hydraulic vibratory hammer.

Machine

Driving work

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50

Extraction length L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(19) Embankment on Left Bank

The embankment on the left bank is constructed.

① Excavation

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on left bank

Filling-in of the double sheet coffer dam: 14,280 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(20) Removal of Temporary Bridge

The superstructure work includes installation, deck plate work and handrail installation and the machine used is a crawler crane with 50 tons lift capacity.

The substructure work is performed by crawler crane with 50 tons lift capacity and hydraulic vibratory hammer, and the pier piles are extracted.

Machine:	Maximum N value	N max < 50
	Extraction length	9.3 m < 25 m (H350 steel)

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer)

(21) Building Work

The integrated water management centre is built on the premises of the Egyptian Irrigation Department, A two-storey building is constructed.

2-2 Construction of the Badraman Regulator

The Badraman regulator is constructed at the same time as construction of the Bahr Yusef regulator.

(1) Preparation Work

In the preparation work, preparations for construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment on Upstream Side

First of all, work on the embankment of the entrance road on the upstream side starts.

① Transportation from borrow site

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(3) Sheet Pile Work on Upstream Side

The sheet piles are driven in the upstream embankment.

① Machine

Sheet pile driving work (driving length 6 m)

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	6 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (46 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

(4) Entrance Road Embankment on Downstream Side

The embankment of the entrance road on the downstream side is constructed.

① Transport from borrow site

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(5) Sheet Pile Revetment Work (Downstream)

The sheet pile revetment is constructed on the downstream side and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment work are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6 m, H-250 3.7 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile: 53 piles, driving length: 6 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 31 at less than 6 m in length.

③ Driving work (H-250 steel pile: 17 piles, driving length: 3.7 m)

Driving work: the number of piles installed per day is 44 at less than 6 m in length.

(6) Sheet Pile Work on Downstream Side (Straight line)

The sheet piles are installed on the downstream side and the sheet pile type is anchorage by H-steel.

The sheet piles and H-steel piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6 m, H-250 3.7 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile: 34 piles, driving length: 6 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 31 at less than 6 m in length.

③ Driving work (H-250 steel pile: 12 piles, driving length: 3.7 m)

Driving work: the number of piles installed per day is 44 at less than 6 m in length.

(7) Temporary Bridge

The embankment coffer dam for the Badraman regulator is constructed on the upstream side and a temporary bridge is also constructed at the Diroutiah canal. The embankment coffer dam and the temporary bridge are used as the construction road across the Badraman canal. The temporary bridge is 30 m long and 8 m wide. The temporary bridge is made of steel and the construction work is divided into superstructure and substructure. The construction of the bridge piers as the substructure is advanced first and the superstructure is constructed.

(a) Superstructure

② Installation work	Weight of steel: 24.0 tons, crawler crane with 50 tons lift capacity
② Deck plate work	Area: 240.0 m^{2,} crawler crane with 50 tons lift capacity
③ Handrail installation	Length: 60 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 5.3 m

Machine: Maximum N value	N max < 50
Driving length	5.3 m < 25 m (H300 steel)

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 28 piles

② Installation of pier piles

Weight of steel: 29.7 tons, Machine: Crawler crane with 50 tons lift capacity

(8) Excavation and Embankment

The excavation and embankment works on the construction site are performed. The excavated soil is stocked on the construction site and used for backfill.

① Excavation

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfill embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(9) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetment for the Badraman regulator is constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6.5 m, 7.95 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	6.5 m, 7.95 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 7.95 m, PU18 (equivalent to Type IIIw) 11 piles

Driving work: the number of piles installed per day is 29.

Sheet pile, driving length 6.5 m, PU12 (equivalent to Type IIw) 6 piles

Driving work: the number of piles installed per day is 33.

(10) Waterstop Sheet Pile (Gate Structure)

The waterstop sheet piles for the Badraman regulator are installed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 2.0 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	2.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 28 piles

Driving work: the number of piles installed per day is 55.

(11) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method
2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at the construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with a 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete placement should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 28.2 m in length and the total volume of concrete is 770 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting Method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

- The maximum casting volume is approximately 200 m^3 per day.

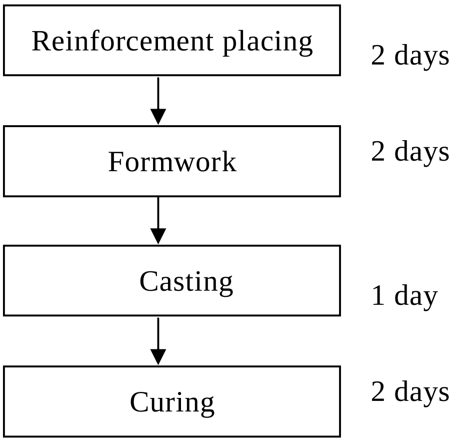
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.

Base of gates
Piers of gates
Bridge area of gates

② Casting capacity

The volume of concrete per block is approximately 150 m^3 and the casting capacity including preparations is as follows:

Concrete casting: one day including preparations
Demoulding: four days for cross section formwork



The number of workable days is considered except the curing days.

Number of days per cycle (except curing) =2+2+1=5 days (pier area)

After completion of the casting at the pier, work starts on the next block and the number of curing days is decided as 2 days.

The casting interval is normally a cycle of 5+2=7 days.

(12) Bed Protection Work on Downstream Side

The riprap material is brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.
The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.
The riprap material is spread by 21 tons bulldozer.

(13) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(14) Removal of Temporary Bridge

The superstructure and substructure are removed.

(15) Sheet Pile Removal on Upstream Side

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

(16) Removal of Sheet Pile Revetment Downstream

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

2-3 Construction of the Diroutiah Regulator

The construction of the Diroutiah regulator is performed after the construction of the Badraman regulator.

(1) Preparation work

In the preparation work, preparations for construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment on Upstream Side

The embankment of the entrance road on the upstream side is constructed with embankment material from the Badraman work.

① Transport from the Badraman embankment

Embankment on the upstream side: 2,100 m^3

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

Embankment: 2,100 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the Badraman site directly.

(3) Sheet Pile Work on Upstream Side

The sheet piles are driven into the upstream embankment.

① Machine

Sheet pile driving work (driving length 6 m)

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value	N max < 50
Driving length	6 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (46 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

(4) Entrance Road Embankment on Downstream Side

The embankment of the entrance road on the downstream side is constructed first.

① Transport from Badraman site

Embankment on the downstream side: 336 m^3

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on the downstream side

Embankment: 336 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the Badraman site directly.

(5) Sheet Pile Revetment Work (Downstream)

The sheet pile revetment is constructed on the downstream side and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6 m, H-250 3.7 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile: 53 piles, driving length: 6 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 31 at less than 6 m in length.

③ Driving work (H-250 steel pile: 17 piles, driving length: 3.7 m)

Driving work: the number of piles installed per day is 44 at less than 6 m in length.

(6) Temporary Bridge

The embankment coffer dam for the Diroutiah regulator is constructed on the upstream side and a temporary bridge is also constructed over the Badraman canal. The embankment coffer dam and the temporary bridge are used as the construction road across the Badraman canal. The temporary bridge is 30 m long and 8 m wide. The temporary bridge is made of steel and the construction work is divided into superstructure and substructure. The construction of the bridge piers as the substructure is advanced first and the superstructure is constructed.

(a) Superstructure

②	Installation work	Weight of steel: 24.0 tons, crawler crane with 50 tons lift capacity
②	Deck plate work	Area: 240.0 $m^{2,}$ crawler crane with 50 tons lift capacity
③	Handrail installation	Length: 60 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 5.3 m

Machine	Maximum N value	N max < 50
	Driving length	5.3 m < 25 m (H-300 steel)

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 28 piles

② Installation of pier piles

Weight of steel: 29.7 tons, Machine: Crawler crane with 50 tons lift capacity

(7) Excavation and Embankment

The excavation and embankment works on the construction site are performed. The excavated soil is stocked on the construction site and used for backfill.

① Excavation

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfill embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(8) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetments on the right and left banks of the Badraman regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 6.65 m, 7.10 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	6.65 m, 7.10 m <15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 6.65 m, PU12 (equivalent to Type IIw) 7 piles

Driving work: the number of piles installed per day is 33.

Sheet pile, driving length 7.1 m, PU12 (equivalent to Type IIw) 11 piles

Driving work: the number of piles installed per day is 33.

(9) Waterstop Sheet Piles (Gate Structure)

The waterstop sheet piles are installed for the Diroutiah regulator. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine
Driving work: Driving length: sheet pile 2.0 m
Machine: Hydraulic vibratory hammer
Maximum N value N max < 50
Driving length 2.0 m < 15 m
Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work
Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 19piles
Driving work: the number of piles installed per day is 55.

(10) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.
Concrete placement conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method

2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 27.7 m in length and the total volume of concrete is 987 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting method

The casting is done by 50 tons crane and the volume of casting per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

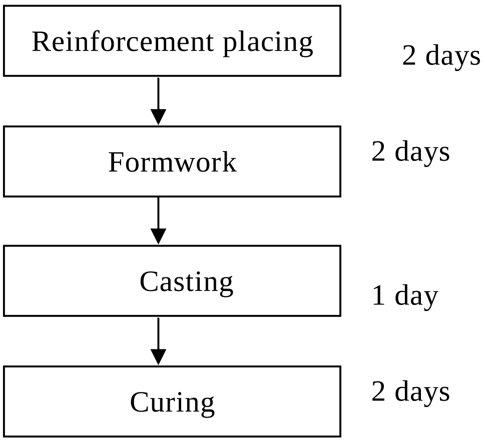
The casting schedule is decided based on the following conditions:

- The maximum volume of concrete casting is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.
    - Base of gates
    - Piers of gates
    - Bridge area of gates

② Casting capacity The volume of concrete per block is approximately 150 m^3 and the casting capacity including the preparations is as follows:

Casting: one day including preparations

Demoulding: four days for cross section formwork



The number of workable days is considered except the curing days.

Number of days per cycle (except curing) = 2+2+1 = 5 days (pier area)

After completion of the pier casting, work starts on the next block and the number of workable days for curing is decided as 2 days.

The casting interval is normally a cycle of 5+2 = 7 days.

(11) Bed Protection Work on Downstream Side

The riprap material is brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck

The riprap material is spread by 21 tons bulldozer.

(12) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(13) Removal of Temporary Bridge

The superstructure and substructure are removed.

(14) Removal of Sheet Piles on Upstream Side

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

(15) Removal of Sheet Pile Revetment Downstream

The sheet piles are removed by hydraulic vibratory hammer and crawler crane with 50 tons lift capacity.

2-4 Construction of Ibrahimia Regulator

The construction of the Bahr Yusef regulator begins after the relocation and demolition of the mosque on the left bank.

(1) Preparation work

In the preparation work, preparations for the construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment on Upstream Side

The entrance road embankment on the upstream side is constructed with embankment material from the Diroutiah work. The borrow site is located 19 km from the construction site near the spoil bank site.

・Diroutiah

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Embankment material deficiency

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Entrance road embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(3) Excavation and Embankment Work (Railway Side)

The embankment material for the sheet pile work on the railway side is the excavated material from the riverbed portion.

・Excavation of riverbed portion

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

・Embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly. The remaining excavated material is used for the embankment on the downstream side.

(4) Sheet Pile Work on Railway Side

The sheet piles on the railway side are driven in by hydraulic press-in machine.

① Machine

Sheet pile driving work (driving length 8 m)

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	8 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (PU28+1 (equivalent to Type IVw) 195 piles, driving length 8 m)

The number of the piles installed per day is 25.

(5) Bed Protection Work

The riprap material is brought from the quarry site for the riprap and masonry work near Assiut.

The transport distance is 60 km.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(6) Entrance Road Embankment on Downstream Side

The entrance road embankment on the downstream side is constructed with the excavated material and embankment material on the railway side. The material from the railway side is used after completion of the sheet pile work.

① Excavation

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on the downstream side

Embankment: 3,273 m^3

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(7) Temporary Cradle

After the construction of the temporary bridge, work goes ahead on the temporary cradle (width 6 m). The double sheet coffer dam sheet piles are driven in from the temporary cradle. The temporary cradle is constructed first and driving of the sheet piles is performed at the same time. The temporary cradle is 215 m long and 6 m wide. The temporary cradle is made of steel and the construction work is divided into superstructure and substructure. The cradle piers are constructed first as the substructure, and the superstructure is constructed.

(a) Superstructure

② Installation work	Weight of steel: 184.9 tons, crawler crane with 50 tons lift capacity
② Deck plate work	Area: 1,296 m^2, crawler crane with 50 tons lift capacity
③ Handrail installation	Length: 430 m, crawler crane with 50 tons lift capacity

(b) Substructure

① Pier pile driving work

・Driving length: 7.5 m

Machine:	Maximum N value	N max < 50	
	Driving length	7.5 m < 25 m (H400 steel)	
	Extraction length	7.5 m < 25 m	Hydraulic vibratory hammer

Ancillary machine: Crawler crane with 50 tons lift capacity (Hydraulic vibratory hammer) 148 piles

② Installation of pier piles Weight of steel: 291.4 tons, crawler crane with 50 tons lift capacity

(8) Double Sheet Coffer Dam

The double sheet coffer dam is installed along with the temporary cradle work. The sheet pile driving and extraction work is performed by hydraulic vibratory hammer.

① Machine

Sheet pile driving work

Driving length: 11 m

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile (PU28+1 (equivalent to Type IVw), outside: 381 piles, driving length 11 m, inside: 331 piles, driving length 10 m)

Connection of the sheet piles is performed from the temporary cradle. The number of piles installed per day is 20 at less than 12 m in length (including the connection work).

(9) Double Sheet Coffer Dam Embankment and Removal of Temporary Cradle

After the installation of the double sheet coffer dam, the double sheet coffer dam embankment is constructed and the temporary cradle is removed.

① Embankment material

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Double sheet coffer dam embankment

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(10) Excavation Work on Lower Left Side

The excavation work on the lower left side is performed and the excavated material is stocked on the left embankment of the Bahr Yusef regulator.

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The embankment at the stock pile is compacted by 10 tons vibrating roller.

(11) Sheet Pile Revetment Work on Lower Left Side

The sheet pile revetment on the lower left side is constructed and the revetment type is anchorage by H-steel. The revetment sheet piles and H-steel piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 8 m, H-250 4.1 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	8 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile PU28+1 (equivalent to Type IVw): 200 piles, driving length: 8 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 25 at less than 9 m in length.

③ Driving work (H-250 steel pile: 68 piles, driving length: 4.1 m)

Driving work: the number of piles installed per day is 37 at less than 6 m in length.

(12) Excavation Work on Upper Left Side

The excavation work on the upper left side is performed and the excavated material is stocked on the left embankment of the Bahr Yusef regulator.

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The embankment at the stock pile is compacted by 10 tons vibrating roller.

(13) Sheet Pile Revetment Work on Upper Left Side

The sheet pile revetment on the upper left side is constructed and the revetment type is anchorage by H-steel. The sheet piles and H-steel piles for the revetment are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 3 m, H-250 2.5m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	3 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (sheet pile PU28+1 (equivalent to Type IVw): 223 piles, driving length: 3 m)

Sheet pile, PU28+1 (equivalent to Type IVw)

Driving work: the number of piles installed per day is 223 at less than 3 m in length.

③ Driving work (H-250 steel pile: 68 piles, driving length: 3.0 m)

Driving work: the number of piles installed per day is 48 at less than 4 m in length.

(14) Demolition of Slope on Left Bank

The demolition and removal of the slope on the left bank are performed by backhoe and the generated rubble is loaded by backhoe and transported by dump truck. The generated rubble is stocked on the left embankment of the Bahr Yusef regulator.

(15) Drainage Work

The drainage of the percolation from the foundation surface of the double steel sheet piles is conducted using the pump drain method and well point method, both separately and in combination. The construction site of the double steel sheet piles is surrounded by canal water and it is therefore necessary to select a drainage method that ensures smooth progress of the construction work, as the foundation surface of the excavation is highly permeable

As the foundation conditions are such that there are thick geological layers with high permeability (silty clay and sand etc.), the combination of the pump drain and well point methods is selected for the drainage work on the site. It is necessary to check the turbidity of the drainage water to prevent piping.

① Installation and removal of well-points (length 360 m, interval 3 m, 120 well points)
② Installation and removal of well-point pumps (2 pumps, 2 spare pumps)

(16) Excavation Work

The excavation work in the site area is performed. The excavated material is loaded on the dump truck by backhoe and stocked on the left embankment of the Bahr Yusef regulator.

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The embankment at the stock pile is compacted by 10 tons vibrating roller.

(17) Foundation Pile Work

Cast-in-place concrete piles are planned for the foundation of the regulator and the bored pile method is applied as the construction method. The excavation is done by earth auger and bentonite is used to secure the walls of the hole. The bore hole machine is a 42 tons crawler crane and the construction capacity is 3 piles per day.

(18) Waterstop Sheet Piles

The sheet piles are driven in by hydraulic vibratory hammer.

① Machine

Sheet pile driving work (driving length 4.5 m, 6 m, 12 m)

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value	N max < 50
Driving length	4.5 m, 6 m, 12 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, PU12 (equivalent to Type IIw), outside: 60 piles, driving length 4.5 m
The number of piles installed per day is 40.

Sheet pile, PU12 (equivalent to Type IIw), outside: 59 piles, driving length 6.0 m
The number of piles installed per day is 40.
Sheet pile, PU12 (equivalent to Type IIw), outside: 60 piles, driving length 12.0 m
The number of piles installed per day is 40.

(19) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method
2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during concrete casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate is a long structure on the upstream side with a length of 27.9 m and on the downstream side, with a length of 23.5 m. The total volume of concrete is 6,022 m^3.

(d) Basic Conditions

① Specifications of concrete

Concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

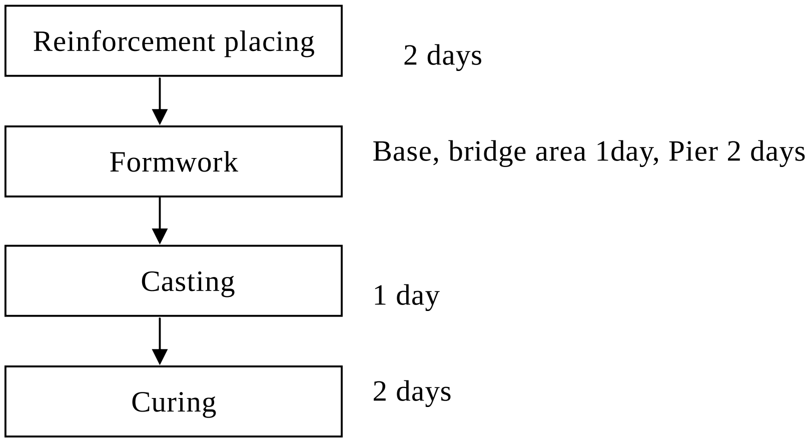
- The maximum casting volume is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 5 parts.
  - Base of gates on upstream side
  - Piers of gates on upstream side
  - Bridge area of gates on upstream side
  - Base of apron on downstream side
  - Wall of apron on downstream side

② Casting capacity

The volume of concrete per block is approximately 200 m^3 and the casting capacity including the preparations is as follows:

Casting concrete: one day including preparations

Demoulding: four days for cross section formwork



The workable days are considered except curing days.

1 casting cycle (except curing) =2+1+1=4 days (base, bridge area)

=2+2+1=5 days (pier area)

After completion of the casting at the pier, work on the next block starts and the number of workable days for curing is decided as 2 days.

The interval for concrete casting is normally a cycle of 5+2=7 days.

(20) Embankment on Left Side

The embankment on the left side is constructed after the concrete work for the regulator. The embankment is compacted by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(21) Installation of Gates and Trial Operation

The installation of the gates takes 2 months of the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(22) Excavation for Double Sheet Coffer Dam and Embankment on Left Bank

The excavation and transport of soil for the double sheet coffer dam are performed and the embankment on the right bank is constructed.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on right bank

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(23) Removal of Double Sheet Coffer Dam

The double sheet coffer dam is removed by hydraulic vibratory hammer.

① Machine

Extraction length: 11 m

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Extraction length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Extraction work (outside: 381 piles, length 11 m, inside: 331 piles, length 10 m)

The number of piles extracted per day is 50 at less than 12 m in length.

(24) Sheet Pile Revetment Work

The sheet pile revetment work is performed by hydraulic vibratory hammer.

① Machine

Driving work

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Extraction length	L < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(25) Embankment on Right Bank

The embankment on the right bank is constructed with material from the stock pile and the backfill from the double sheet coffer dam.

① Excavation

The transport distance is 0.3 km within the site area.
The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment on left bank

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

2-5 Construction of the Abo Gabal Regulator

The construction of the Abo Gabal regulator is performed after the construction of the Diroutiah regulator.

(1) Preparation Work

In the preparation work, the preparations for construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment

The material for the embankment work for the entrance road is transported from the borrow site.

① Transport from the borrow site

The transport distance is 19 km from the borrow site.
The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(3) Diversion Canal Sheet Pile Work

The sheet piles or the diversion canal are constructed.

① Machine

Sheet pile driving work (driving length 5 m)
Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (PU28+1 (equivalent to Type IVw) outside 92 piles, inside: 75 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

③ Excavation

The excavation is performed inside the sheet piles and the excavated soil is used for backfill for the double sheet coffer dam.

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

④ Superstructure

・Installation work	Weight of steel: 3.9 tons, crawler crane with 50 tons lift capacity
・Deck plate work	Area: 54 m^2,crawler crane with 50 tons lift capacity
・Handrail installation	Length: 39 m, crawler crane with 50 tons lift capacity

(4) Double Sheet Coffer Dam Embankment

Backfilling of the double sheet coffer dam is advanced first.

① Excavation and transport

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfilling of the double sheet coffer dam

The spreading and compaction of the embankment material is done by 11 tons bulldozer.

(5) Double Sheet Coffer Dam

The double sheet coffer dam is constructed. The sheet pile driving and extraction work is done by hydraulic vibratory hammer.

① Machine

Sheet pile driving work

Driving length: 5 m

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, PU28+1 (equivalent to Type IVw), outside: 116 piles, driving length 5 m, inside: 80 piles, driving length 5 m)

The connection of the sheet piles is performed from the temporary cradle. The number of piles installed per day is 31 at less than 6 m in length.

(6) Excavation Work

The excavation work is performed. The excavated material is stocked in the site area and used for backfill.

Excavation: 1,510 m^3

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(7) Backfilling

The embankment is constructed and the embankment is compacted by 4 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(8) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetments on the right and left banks of the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 4.6 m, 5.0 m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 4.6 m, 5.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 4.6 m, PU12 (equivalent to Type IIw) 75 piles

Driving work: the number of piles installed per day is 33.

Sheet pile, driving length 5.0 m, PU12 (equivalent to Type IIw) 72 piles

Driving work: the number of piles installed per day is 33.

(9) Waterstop Sheet Piles (Gate Structure)

The waterstop sheet piles for the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 2.0 m

Machine: Hydraulic vibratory hammer

Maximum N value N max < 50

Driving length 2.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 24 piles

Driving work: the number of piles installed per day is 55.

(10) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method
2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 27.9 m in length and the total volume of concrete is 1,441 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

③ Casting method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

The casting schedule is decided based on the following conditions:

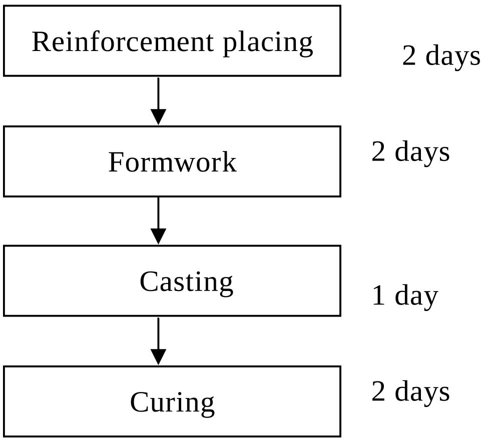
- The maximum volume of cast concrete is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.

Base of gates
Piers of gates
Bridge area of gates

② Casting capacity

The volume of concrete per block is approximately 150 m^3 and the casting capacity including the preparations is as follows:

Casting: one day including preparations
Demoulding: four days for cross section formwork



The workable days are considered except curing days.

1 casting cycle (except curing) =2+2+1=5 days (pier area)

After completion of the casting at the pier, work starts on the next block and the number of workable days for curing is decided as 2 days.

The casting interval is normally a cycle of 5+2=7 days.

(11) Installation of Gates and Trial Operation

The installation of the gates takes 2 months for the 4 guide frames and another 2 months for the 4 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(12) Excavation for Double Sheet Coffer Dam and Removal of Sheet Piles

The excavation and transport of backfill for the double sheet coffer dam are performed and stocked on the left bank of Bahr Yusef.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Stockpile

The spreading and compaction of the embankment are done by 11 ton bulldozer.

③ Removal of Sheet Piles

Extraction length: 11m

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Extraction length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(13) Removal of Diversion Canal and Backfilling

Removal of diversion canal (sheet piles and superstructure)

Backfill: The spreading and compaction of the embankment are done by 11 tons bulldozer.

(14) Removal of Entrance Road

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The spreading and compaction of the embankment are done by 11 tons bulldozer.

2-6 Construction of the Sahelyia Regulator

The construction of the Sahelyia regulator is performed after the construction of the Abo Gabal regulator.

(1) Preparation Work

In the preparation work, preparations for the construction, investigation, surveying, staking, clearing and cutting, stumping and land grading are performed. The period of the preparation work is one month.

(2) Entrance Road Embankment

The embankment material for the entrance road is transported from the borrow site.

① Transport from the borrow site

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Embankment of entrance road

The embankment is constructed by 10 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought from the borrow site directly.

(3) Diversion Canal Sheet Pile Work

The sheet piles for the diversion canal are installed.

① Machine

Sheet pile driving work (driving length 5 m)

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Driving length	5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work (PU28+1 (equivalent to Type IVw) outside: 89 piles, inside: 76 piles, driving length 6 m)

The number of piles installed per day is 31 at less than 6 m in length.

③ Excavation

The excavation is performed inside the sheet piles and the excavated soil is used for backfill for the double sheet coffer dam. (Excavation 307 m^3)

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

④ Superstructure

・Installation work	Weight of steel: 7.8 tons, crawler crane with 50 tons lift capacity
・Deck plate work	Area: 108 m^2, crawler crane with 50 tons lift capacity
・Handrail installation	Length: 72 m, crawler crane with 50 tons lift capacity

(4) Embankment of Double Sheet Coffer Dam

The backfilling of the double sheet coffer dam is advanced first.

① Excavation and transport

The transport distance is 19 km from the borrow site.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Backfilling of the double sheet coffer dam

The spreading and compaction of the embankment material are done by 11 tons bulldozer.

(5) Double Sheet Coffer Dam

The double sheet coffer dam is constructed. The sheet pile driving and extraction work is done by hydraulic vibratory hammer.

① Machine

Sheet pile driving work

Driving length: 5 m

Construction method: Hydraulic vibratory hammer

Machine: Maximum N value N max < 50
Driving length 5 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, PU28+1 (equivalent to Type IVw), outside: 115 piles, driving length 5 m, inside: 77 piles, driving length 5 m)

The connection of the sheet piles is performed from the temporary cradle. The number of piles installed per day is 31 at less than 6 m in length.

(6) Excavation Work

The excavation work is performed. The excavated material is stocked in the site area and used for backfill.

The transport distance is 0.1 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

(7) Backfilling

The embankment is constructed and compacted by 4 tons vibrating roller. The finished thickness is 40 cm and the number of compactions is 6. The embankment material is brought directly.

(8) Sheet Pile Revetment Work (Gate Structure)

The sheet pile revetments on the right and left banks of the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 5.75 m, 5.0 m

Machine: Hydraulic vibratory hammer
Maximum N value N max < 50
Driving length 5.75 m, 5.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 5.75 m, PU12 (equivalent to Type IIw) 32piles

Driving work: the number of piles installed per day is 33.

Sheet pile, driving length 5.0 m, PU12 (equivalent to Type IIw) 32 piles

Driving work: the number of piles installed per day is 33.

(9) Waterstop Sheet Piles (Gate Structure)

The waterstop sheet piles for the Abo Gabal regulator are constructed. The sheet piles are driven in by hydraulic vibratory hammer.

① Construction Machine

Driving work: Driving length: sheet pile 2.0 m

Machine: Hydraulic vibratory hammer

Maximum N value	N max < 50
Driving length	2.0 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

② Driving work

Sheet pile, driving length 2.0 m, PU12 (equivalent to Type IIw) 14 piles

Driving work: the number of piles installed per day is 55.

(10) Concrete Work

The NDGR is a mass concrete structure with a high concrete placement volume. A method to ensure a high quality, stable supply of mass concrete shall be considered in order to prevent temperature cracks caused by heat of hydration.

Concrete placing conditions:

1) Ensuring quality: Unit concrete placement volume, concrete curing method
2) Ensuring a stable supply (production method): Procurement from an existing ready-mixed concrete plant or production by concrete batching at construction site

(a) Concrete production

Two concrete plants are located in this area, one in Minia and the other in Assiut, both within a radius of 100 km and a distance of one hour from the construction site, but they cannot be relied upon. In the construction plan, the contractor needs to cast 6,000 m^3 of concrete in 8 months, so a large volume of concrete of stable quality must be provided. There is a scheduled plan to install a concrete plant with 30 m^3/hr production capacity in the temporary yard adjacent to the construction site. This will produce a volume of 250 m^3 per day.

(b) Concrete casting

The contractor determines the appropriate segment block for concrete casting and uses a Japanese reusable plywood formwork when placing the concrete, taking into account the structural stress, construction joints, water-tightness, and concrete production and casting ability. Considering that the summer temperature in Egypt reaches 40ºC, concrete casting should be done during the night when the temperature drops. It is necessary to take into account cracks and hot weather concrete during concrete casting of the weir apron and bridge abutment as they are mass concrete structures.

(c) Outline of Construction

The gate structure is 28.8 m in length and the total volume of concrete is 752 m^3.

(d) Basic Conditions

① Specifications of concrete

The concrete is produced at the batching plant and transported to the site. The maximum size of the coarse aggregate is 40 mm, and the slump value is 8~12 cm.

② Concrete casting

The maximum lift height is 3.5 m.

⑤ Casting method

The casting is done by 50 tons crane and the casting volume per day is 200 m^3.

④ Formwork

The formwork is made of wood.

(e) Casting schedule

① Casting schedule

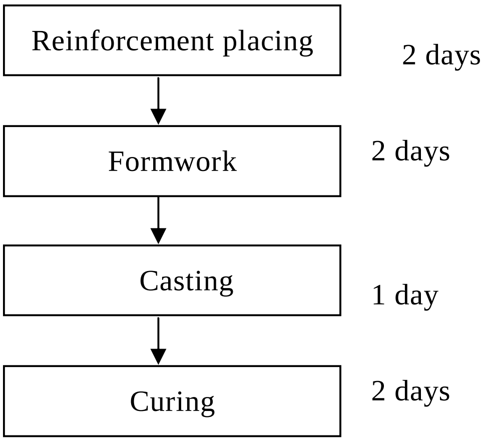
The casting schedule is decided based on the following conditions:

- The maximum casting volume is approximately 200 m^3 per day.
- The maximum height of one lift is 3.0 m.
- The concrete joints are treated by green cutting, etc.
- The casting schedule is decided by the structure scale and the casting is divided into 3 parts.
  - Base of gates
  - Piers of gates
  - Bridge area of gates

② Casting capacity

The volume of concrete per block is approximately 150 m^3 and the casting capacity including the preparations is as follows:

Casting concrete: one day including preparations
Demoulding: four days for cross section formwork



The workable days are considered except curing days.

1 casting cycle (except curing) =2+2+1=5 days (pier area)

After completion of the casting at the pier, work starts on the next block and the number of workable days for curing is decided as 2 days.

The interval for concrete casting is normally a cycle of 5+2=7 days.

(11) Installation of Gates and Trial Operation

The installation of the gates takes 1 month for the 2 guide frames and another month for the 2 gates and 4 hoisting devices.

After the installation of the gates, trial operation is performed before the removal of the coffer dam, and the operation and control conditions are confirmed. After the removal of the coffer dam and the flow of water through the gates, trial operation and instruction in operation are planned.

(12) Excavation for Double Sheet Coffer Dam and Removal of Sheet Piles

The excavation and transport of backfill for the double sheet coffer dam are performed and stocked on the left bank of Bahr Yusef.

① Excavation

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

② Stockpile

The spreading and compaction of the embankment is done by 11 tons bulldozer.

③ Removal of Sheet Piles

Extraction length: 11 m

Construction method: Hydraulic vibratory hammer

Machine:	Maximum N value	N max < 50
	Extraction length	11 m < 15 m

Ancillary machine: Crawler crane with 50 tons lift capacity

(13) Removal of Diversion Canal and Backfilling

Removal of diversion canal (sheet piles and superstructure)

Backfill: The spreading and compaction of the embankment are done by 11 tons bulldozer.

(14) Removal of Entrance Road

The transport distance is 0.3 km within the site area.

The combination of loading and transport is backhoe loading 1.4 m^3 + 10t dump truck.

The spreading and compaction of the embankment are done by 11 tons bulldozer.

2-7 Construction of water management sysytem

(1) Location of construction

The contractor conducts a field survey before construction and confirms construction conditions (installation path of vehicle, installation site of equipment, machinery and equipment necessary for construction etc.). The installation location shall be the location shown in the table below.

Table 2-7.1 Location of the construction of water management system

Irrigation facilities			Name of the Target facilities		No.
Regulator	Bahr Yusef canal		Dahab Regulator	Lahoun Regulator	6
			Sakoula Regulator	Abo El Shekok Regulator	
			Mazoura Regulator	Regulator km39	
	Ibrahimia canal		New Hafze Regulator	Sharahna Regulator	6
			Matay Regulator	El Gandy Regulator	
			Maghagha Regulator	Ashmont Regulator	
Branch canal	Bahr Yusef canal	Intake	Manshat EL Dahab	Quftan	6
			El Hareka	Wesh El-Bab	
			El Sabaa	EL-Giza	
		Weir	Hassan Wasef Weir		1
		Pump	New Kamdeer P.S.	Old Sakoula P.S.	5
			New Terfa P.S.	Mazoura P.S.(2)	
			Old Terfa P.S.		
	Ibrahimia canal	Intake	Irad El Maharak	Gendia	10
			El Kosia	Abo Shosha	
			East Hafze	EL Soultany	
			West Hafze	Tansa	
			Adkak	El Mansour	
		Weir	Serry Weir	Maghagha Weir	2
Ibrahimia main canal			Ibrahimia Head Regulator		1
Lake			Quarun Lake		1
Total					38

(2) Contents of construction works

The construction will be the new construction works of 38 observation stations, one central monitoring station and one monitoring station, mainly consisting of the following contents.

① Installation and adjustment of the central monitoring station (Server, Laptop, Network facilities, Display panel, etc.)

② Installation and adjustment of the monitoring station (Server, Laptop, Network facilities, Display panel, Dater logger, Modem, etc.)

③ Installation and adjustment of the monitoring equipments (Fence, Pole, Water level sensor, Solar panel,

④ Installation of wiring and conduit

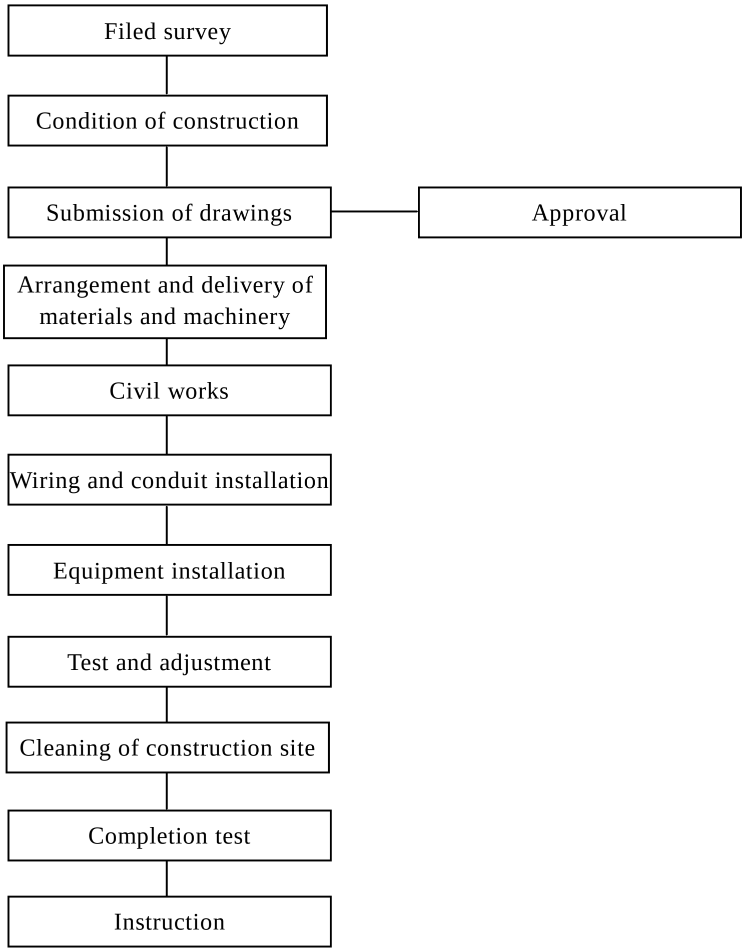
(3) Flow of construction works

① General items

This construction will be implemented according to the civil works specifications and electrical works specifications in Egypt.

② Overall plan

The main procedures from field survey to completion of construction are as follows.


Filed survey
Condition of construction
Submission of drawings
Approval
Arrangement and delivery of materials and machinery
Civil works
Wiring and conduit installation
Equipment installation
Test and adjustment
Cleaning of construction site
Completion test
Instruction

(4) Test and adjustment

① Inspection

In the completion inspection, the necessary personnel, materials, equipment, measuring instruments, etc. shall be prepared by the contractor.

② Test

Various test adjustments shall be carried out under supervision staff witnessing. However, if supervisory staff could not attend, the contractor shall submit a report of the test results with photographs.

(5) Construction period

Based on the construction contents and method described above, the standard periods of construction in each process are as follows.

① Planning and designing : Two months

② Equipment procurement, material arrangement and loading, acceptance inspection : Three months

③ Civil works : Two months

④ Electrical works : Two months

⑤ Planning and designing : Two months

From the above, the total period for this construction works will be 9.5 months. In addition, in parallel with the above civil works and electrical works, software development will be carried out. The construction period for software development will be assumed to be 10 months.

Assuming simultaneous execution of civil engineering works, electrical work and software development period, the period of water management construction complete shall be 12.5 months.

3. Work Schedule

3-1 Criteria on work schedule

(1) Critical path work

Bahr Yusef construction work is to be carried out first, followed by Ibrahimia construction work. In order to even out the work volume and reduce the project cost; temporary material and heavy machinery such as double sheet piles and temporary bridges are to be reutilized in each construction.

(2) Work procedure

The work procedure is shown in Figure 3-1.1.

(3) Conditions of project period

- Working days coefficient[1]: 1.35
- Yearly working days: 270 days/year (=365/1.35)
- Monthly working days: 22.5 days/month (=270/12)
- Daily working time: 8:00-17:00 (working hours: 8 hours/day, excluding one hour break)

3-2 Formulation of work schedule

The critical path schedule has set the Bahr Yusef construction work first, followed by Ibrahimia. Other works at Badraman, Abo Gabal, and Saheliya are scheduled based on the principle that work volume can be leveled throughout the construction period. The critical path work for Bahr Yusef and Ibrahimia construction work are as follows.

(1) Critical path work

Preparatory work → Temporary bridge and Platform for Driving Sheet pile inside of Coffer Dam→ Temporary double sheet pile coffer dam work →Embankment for Temporary Road & Hardening for Soft Soil→ excavation inside dam → Foundation pile work & cut-off sheet pile → Structure concrete work → Installation work of gate facility and commissioning → Removal work of temporary bridge and coffer dam and changing water flow → Embankment and Sheet pile for Bank protection and gabion and permanent road etc. → Overall integrated test operating and operation training → Finishing and clearance→Handover.

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[1] Actual days for each work day considering holidays and days where no work is possible

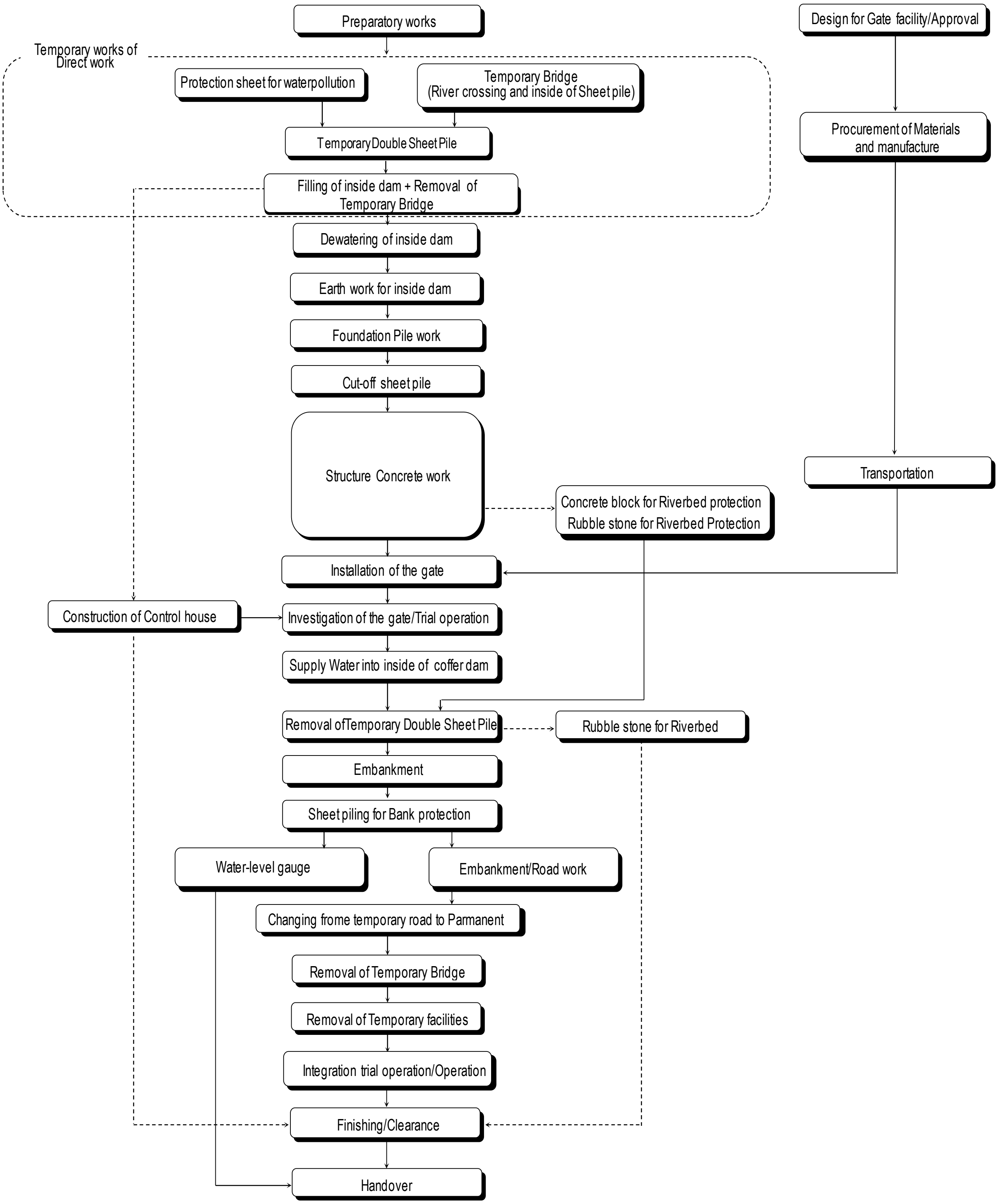

Preparatory works
Design for Gate facility/Approval
Temporary works of Direct work
Protection sheet for waterpollution
Temporary Bridge (River crossing and inside of Sheet pile)
Procurement of Materials and manufacture
Temporary Double Sheet Pile
Filling of inside dam + Removal of Temporary Bridge
Dewatering of inside dam
Earth work for inside dam
Foundation Pile work
Cut-off sheet pile
Structure Concrete work
Transportation
Concrete block for Riverbed protection
Rubble stone for Riverbed Protection
Installation of the gate
Construction of Control house
Investigation of the gate/Trial operation
Supply Water into inside of coffer dam
Removal ofTemporary Double Sheet Pile
Rubble stone for Riverbed
Embankment
Sheet piling for Bank protection
Water-level gauge
Embankment/Road work
Changing frome temporary road to Parmanent
Removal of Temporary Bridge
Removal of Temporary facilities
Integration trial operation/Operation
Finishing/Clearance
Handover

Figure 3-1.1 Work procedure

Works on the manufacturing of mechanical and electric facilities for gates, transportation, construction of the control house, and river bed protection work etc, will proceed in parallel with the structure concrete work, gate facility installation work, and commissioning, etc.

The work schedule of this critical path is found to be the shortest and most economical given the above conditions, the construction period, and standard daytime work conditions.

The overall project period is set for 51 months (Bahr Yusef, 25.5 months, and Ibrahimia, 25.5 months) based on the final design and quantity.

Bahr-Yusef

Table 3-2.1 Critical pass work (Bahr Yusef) (1/5)

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
gate manufacture	design･approval	1	lot			90	1	90	-	0
	material procurement	1	lot			60	1	60	-	
	manufacture･inspection at factory	1	lot			135	1	135	-	
preparatory work	procurement/temporary office/temporary yard/transportation	1	lot			150	1	150	90	90
Direct temporary work	setting barge for dredging for diversion canal		m3	190	2	0.0	1.35	0	-	0
	dredging for diversion canal									
	stone riprap for riverbed									
	removing barge for dredging for diversion canal									
across the canal	erection of temporary bridge									143
	preparation	1	lot			3	1	3	3	
	driving H-beam （driving L less 6m）L=14.5	25	pcs	20	1	1.3	1.35	2	2	
	driving H-beam （driving L less 16m）L=21.5	15	pcs	7	1	2.1	1.35	3	3	
	erection for platform	56.5	t	8.3	1	6.8	1.35	9	9	
	installation for steel top deck	336	m2	111	1	3.0	1.35	4	4	
inside of double sheet	driving H-beam （driving L less 6m）L=14.5	20	pcs	20	1	1.0	1.35	1	1	
	driving H-beam （driving L less 16m）L=21.5	124	pcs	7	1	17.7	1.35	24	24	
	erection for platform	209.5	t	8.3	1	25.2	1.35	34	34	
	installation for steel top deck	1,260	m2	111	1	11.4	1.35	15	15	
	filling for inside double sheet	14,280	m3	410	1	34.8	1.35	47	47	
	driving steel sheet pile for cofferdam									129
	Ⅳ-type （driving L less 12m）joint	750	pcs	8	1	93.8	1.35	127	127	
	(PU28+1 W=0.6m L=20.0m)									
	installation for tie-rod	1	lot						2	
Bank protection work	Bank protection by sheet pile(upstream,downstream at right bank)									
	front Ⅲw （riving L less 15m）L=18m C2	15	pcs	10	1	1.5	1.35	2		
	Ⅳw （driving L less 12m）L=20m C1	6	pcs	11	1	0.5	1.35	1		
	frontⅢw （driving L less 9m）L=12m BR2	15	pcs	29	1	0.5	1.35	1		
	Ⅳw （driving L less 12m）L=18m BR1	8	pcs	11	1	0.7	1.35	1		

Table 3-2.2 Critical pass work (Bahr Yusef) (2/5)

	back Ⅱw （driving L less 6m） L=6m PU12	21	pcs	39	1	0.5	1.35	1		
	Ⅱw （driving L less 6m） L=6m PU12	23	pcs	39	1	0.6	1.35	1		
	installation for tie-rod		pcs	40	1	0.0	1.35	0		
	capping concrete	1	lot			30	1.35	41	-	
temporary work										39
	embankment for access road（upstream & downstream）	7,382	m3	410	2	9.0	1.35	12	12	
	embankment for temporary road on bottom area	705	m3	190	1	3.7	1.35	5	5	
	backfill for structure	740	m3	190	1	3.9	1.35	5	5	
	hardening of soft soil（road and structure area）	1,676	m3	190	1	8.8	1.35	12	12	
	curing								3	
	dewatering of inside dam	1	lot			2	1	2	2	
temporary dewatering	wellpoint	1	lot							
removal for ex. structure	all removal (inside coffer dam)	0.00	m3	63	2	0.0	1.35	0	-	
earth work	preparation								3	20
	excavation for structure inside coffer dam	4,790.00	m3	190	2	12.6	1.35	17	17	
	embankment inside coffer dam(right bank)	7,200.00	m3	300	1	24.0	1.35	32		
	backfill	2,900.00	m3	350	2	4.1	1.35	6	-	
riverbed protection	driving cut-off sheet pile									7
	Ⅳw （driving L less 12m）L-12.0m PU-12	60	pcs	28	1	2.1	1.35	3	3	
	Ⅱw （driving L less 6m）L=6.0m PU-12	59	pcs	39	1	1.5	1.35	2	2	
	（driving L less 4m）L=5.0m PU-12	60	pcs	39	1	1.5	1.35	2	2	
	Ⅳw （driving L less 12m）L-22.0m PU-28	1	pcs	8	1	0.1	1.35	0	0	
	Ⅳw （driving L less 9m）L-20.0m PU-28	1	pcs	9	1	0.1	1.35	0	0	
	Ⅳw （driving L less 9m）L-18.0m PU-18	1	pcs	12	1	0.1	1.35	0	0	
	Ⅳw （driving L less 4m） L-12.0m PU-18	1	pcs	42	1	0.0	1.35	0	0	
	cast-inplace concrete pile									52
	φ1000 L=13.50m	72	pcs	3	1	24.0	1.35	32	32	
	φ1000 L=7.50m	32	pcs	3	1	10.7	1.35	14	14	
removing for temporary embankment										
	removing for temporary embankment	1,445		190	2	3.8	1.35	5	5	
Concrete work	main structure lean concrete	153.3	m3	38.3	1	4.0	1.35	5	5	183
	base									
	scaffolding	476	m2	71	1	6.7	1.35	9	4	

Table 3-2.3 Critical pass work (Bahr Yusef) (3/5)

	re-bar	268.92	t	3.3	3	27.2	1.35	37	37	
	formwork	694.36	m2	30	1	23.1	1.35	31	8	
	placing concrete	2,987.97	m3	182.6	1	33	1.35	45	-	
	pier									
	scaffolding	2,816.33	m2	71	1	39.7	1.35	54	4	
	re-bar	233.11	t	3.3	3	23.5	1.35	32	32	
	formwork	2,983.47	m2	30	3	33.1	1.35	45	8	
	placing concrete	2,590.14	m3	84	1	24	1.35	32	1	
	other concrete(support bridge etc)									
	re-bar	22.35	t	3.3	2	3.4	1.35	5	5	
	formwork	402.90	m2	30	3	4.5	1.35	6	3	
	placing concrete	248.30	m3	84	1	3.0	1.35	4	1	
	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	651.9	m3	71	1	9.2	1.35	12	6	
	re-bar	4.1	t	3.3	1	1.3	1.35	2	2	
	formwork	192.0	m2	30	1	6.4	1.35	9	9	
	placing concrete	45.8	m3	48	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	2	2.7	1.35	4		
	support	2,700.00	m3	71	4	9.5	1.35	13		
	re-bar	46.3	t	3.3	2	7.0	1.35	9	9	
	formwork	759.4	m2	30	2	12.7	1.35	17		
	placing concrete	231.8	m3	153.8	1	6	1.35	8	8	
	curing	1	lot			14	1	14	14	
	removal of form･support	3,847.80	m3	71	6	9.0	1.35	12	12	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	

Table 3-2.4 Critical pass work (Bahr Yusef) (4/5)

Concrete work	**upper pier**									26
	scaffolding	463	m2	71	2	3.3	1.35	4	2	
	re-bar	9.82	t	3.3	1	3.0	1.35	4	1	
	formwork	319.99	m2	30	2	5.3	1.35	7	2	
	placing concrete	109.14	m3		2	2.0	1.35	3	1	
	platform for operation									
	suppoort	937.75	m2	71	2	6.6	1.35	9	2	
	re-bar	7.07	t	3.3	1	2.1	1.35	3	1	
	formwork	205.52	m2	30	2	3.4	1.35	5	2	
	placing concrete	78.58	m3		2	2.0	1.35	3	1	
	curing	1	lot	71	2			14	14	
	removal for form, scaffolding & support	1,143.27	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									26
	assemble	1	lot			15	1.35	20	20	
	installation	1	lot			4	1.35	5	5	
control house		1	lot			160	1	160	-	0
riverbed protection	concrete block	494	pcs	5	2	49.4	1.35	67	-	0
	riprup	1,998.00	m2	58.8	1	34	1.35	46	-	
temporary work	removal of temporary access road(ramp)	7,382	m3	300	1	24.6	1.35	33	33	
	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal for steel sheet pile									27
	Ⅳw-type （driving L less 12m）	750	pcs	40	1	18.8	1.35	25	25	
	Ⅲw-type （driving L less 15m）		pcs	43	1	0.0	1.35	0	-	
	tie-rod	1	lot						2	
removal for ex. structure	removal for outside of coffer dam	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	40,800.00	m3	350	2	58.3	1.35	79	79	
	driving sheet pile outside coffer dam Type-A									
	Ⅳw型 （driving L less 23m） L=22.0m	111	枚	6	1	18.5	1.35	25	25	
	Ⅲw型 （(driving L less 6m） L=6.0m	94	枚	39	1	2.4	1.35	3	3	
	capping concrete for steel sheet pile	1	lot			38	1.35	51	26	
		1	lot			30	1.35	41	-	

Table 3-2.5 Critical pass work (Bahr Yusef) (5/5)

	curing	1	lot			5	1	5	-	
	driving sheet pile outside coffer dam Type-BL									
	Ⅳw type （driving L less 12m） L=12.0m	5	pcs	28	1	0.2	1.35	0	4	
	Ⅲw type （driving L less 6m） L=5.0m		pcs	35	1	0.0	1.35	0		
	capping concrete for steel sheet pile	1	lot			38	1.35	51	26	
		1	lot			30	1.35	41	-	
	curing	1	lot			5	1	5	-	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
appurtenant work	embankment for left bank & road work	7,013.73	m3	250	2	14.0	1.35	19		
	curbstone work	625.34	m	22.5	2	13.9	1.35	19		
	base course t=20cm	1,766.29	m2	1,110	1	1.6	1.35	2		
	sub-base courset=20cm	1,766.29	m2	1,110	1	1.6	1.35	2		
	paving（surface）t=5cm	1,766.29	m2	2,300	1	0.8	1.35	1		
	paving（sublayer）t=6cm	1,766.29	m2	2,300	1	0.8	1.35	1		
	Footpath									
	base course t=15cm	306.44	m2	268	1	1.1	1.35	2		
	paving（surface) t=5cm	306.44	m2	940	1	0.3	1.35	0		
commissioning・inspection	commissioning・operation training					30	1	30	-	
temporary work	removal for temporary bridge									0
temporary bridge(across river)	removal H-beam （driving L less 6m）L=14.5	25	pcs	39	1	0.6	1.35	1		
	removal H-beam （driving L less 16m）L=21.5	15	pcs	22	1	0.7	1.35	1		
	removal for platform	56.5	t	8.3	1	6.8	1.35	9		
	removal for steel top deck	336	m2	111	1	3.0	1.35	4		
	removal for inside coffer dam soil	14,280	m3	300	1	47.6	1.35	64		
cleaning・handover						22	1.35	30		
				Critical pass days=			**768**	**days**		768
				Critical pass month=			**25.6**	**months ≒**	**25.5months**	25.6

Ibrahimia

Table 3-2.6 Critical pass work (Ibrahimia) (1/5)

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Direct temporary work	setting barge for dredging for diversion canal									
	dredging for diversion canal									
	stone riprap for riverbed									
	removing barge for dredging for diversion canal									
inside of double sheet	erection of temporary bridge									
	driving H-beam （driving L less 8m）L=14.5 H350	24	pcs	16	1	1.5	1.35	2	2	
	driving H-beam （driving L less 8m）L=14.5 H400	124	pcs	13	1	9.5	1.35	13	13	
	erection for platform	215.5	t	8.3	1	26.0	1.35	35	35	
	installation for steel top deck	1,296	m2	111	1	11.7	1.35	16	16	
	driving steel sheet pile for cofferdam									
	Ⅳ-type （driving L less 12m） joint	712	pcs	8	1	89.0	1.35	120	120	
	(PU28+1 W=0.6m L=20.0m)									170
	installation for tie-rod	1	lot						2	
	filling for inside double sheet	14,620	m3	410	1	35.7	1.35	48	48	
Bank protection work	Bank protection by sheet pile(upstream,downstream at left bank)									0
	frontⅢw （driving L less 9m）L=16m D1PU18	6	pcs	12	1	0.5	1.35	1		
	Ⅳw （driving L less 9m）L=10m D2 PU12	9	pcs	33	1	0.3	1.35	0		
	frontⅢw （driving L less 9m）L=14m E1	5	pcs	16	1	0.3	1.35	0		
	Ⅳw （driving L less 12m）L=8m E2	3	pcs	11	1	0.3	1.35	0		
	backⅡw （driving L less 6m） L=6m PU12	6	pcs	39	1	0.2	1.35	0		
	Ⅱw （driving L less 6m） L=6m PU12	5	pcs	39	1	0.1	1.35	0		
	installation for tie-rod		pcs	40	1	0.0	1.35	0		
	capping concrete	1	lot			30	1.35	41	-	
temporary work										
	embankment for access road（upstream & downstream）	6,545	m3	410	2	8.0	1.35	11	11	
	embankment for temporary road on bottom area	492	m3	190	1	2.6	1.35	3	3	
	backfill for structure	740	m3	190	1	3.9	1.35	5	5	35
	hardening of soft soil（road and structure area）	1,514	m3	190	1	8.0	1.35	11	11	
	curing								3	

Table 3-2.7 Critical pass work (Ibrahimia) (2/5)

	dewatering of inside dam	1	lot			2	1	2	2	
temporary dewatering	wellpoint	1	lot							
removal for ex. structure	all removal (inside coffer dam)	0.00	m3	63	2	0.0	1.35	0	-	
earth work	preparation								3	51
	excavation for structure inside coffer dam	13,540.00	m3	190	2	35.6	1.35	48	48	
	embankment inside coffer dam(right bank)	1,200.00	m3	300	1	4.0	1.35	5		
	backfill	3,700.00	m3	350	2	5.3	1.35	7	-	
riverbed protection	driving cut-off sheet pile									7
	Ⅳw (driving L less 12m) L-12.0m PU-12	60	pcs	28	1	2.1	1.35	3	3	
	Ⅱw (driving L less 6m) L=6.0m PU-12	59	pcs	39	1	1.5	1.35	2	2	
	Ⅱw (driving L less 4m) L=5.0m PU-12	60	pcs	39	1	1.5	1.35	2	2	
	Ⅳw ((driving L less 9m) L-18.0m PU-18	1	pcs	12	1	0.1	1.35	0	0	
	Ⅳw (driving L less 6m) L-16.0m PU-18	1	pcs	13	1	0.1	1.35	0	0	
	Ⅳw (driving L less 6m) L-14.0m PU-12	1	pcs	17	1	0.1	1.35	0	0	
	Ⅳw (driving L less 4m) L-10.0m PU-12		pcs	42	1	0.0	1.35	0	0	
	cast-inplace concrete pile									45
	φ1000 L=15.00m	56	pcs	3	1	18.7	1.35	25	25	
	φ1000 L=7.00m	32	pcs	3	1	10.7	1.35	14	14	
removing for temporary embankment										
	removing for temporary embankment	1,232		190	1	6.5	1.35	9	5	
Concrete work	main structure lean concrete	154.6	m3	38.6	1	4.0	1.35	5	5	221
	base									
	scaffolding	476	m2	71	1	6.7	1.35	9	4	
	re-bar	269.03	t	3.3	2	40.8	1.35	55	55	
	formwork	694.36	m2	30	1	23.1	1.35	31	8	
	placing concrete	2,989.22	m3	182.6	1	33	1.35	45	-	
	pier									
	scaffolding	2,686.54	m2	71	1	37.8	1.35	51	4	
	re-bar	226.40	t	3.3	2	34.3	1.35	46	46	
	formwork	2,712.47	m2	30	3	30.1	1.35	41	8	
	placing concrete	2,515.56	m3	84	1	24	1.35	32	1	
	other concrete(support bridge etc)									
	re-bar	25.51	t	3.3	2	3.9	1.35	5	5	
	formwork	391.87	m2	30	3	4.4	1.35	6	8	
	placing concrete	283.45	m3	84	1	3.4	1.35	5	1	

Table 3-2.8 Critical pass work (Ibrahimia) (3/5)

	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	637.5	m3	71	1	9.0	1.35	12	6	
	re-bar	4.1	t	3.3	1	1.3	1.35	2	2	
	formwork	192.0	m2	30	1	6.4	1.35	9	9	
	placing concrete	45.8	m3	48	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	2	2.7	1.35	4		
	support	2,700.00	m3	71	4	9.5	1.35	13		
	re-bar	46.3	t	3.3	2	7.0	1.35	9	9	
	formwork	759.4	m2	30	2	12.7	1.35	17		
	placing concrete	231.8	m3	153.8	1	6	1.35	8	8	
	curing	1	lot			14	1	14	14	
	removal of form･support	3,847.80	m3	71	6	9.0	1.35	12	12	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									26
	assemble	1	lot			15	1.35	20	20	
	installation	1	lot			4	1.35	5	5	
Concrete work	**upper pier**									12
	scaffolding	463	m2	71	2	3.3	1.35	4	2	
	re-bar	9.82	t	3.3	1	3.0	1.35	4	1	
	formwork	319.99	m2	30	2	5.3	1.35	7	2	
	placing concrete	109.14	m3		2	2.0	1.35	3	1	
	platform for operation									
	suppoort	937.75	m3	71	2	6.6	1.35	9	2	
	re-bar	7.07	t	3.3	1	2.1	1.35	3	1	
	formwork	205.52	m2	30	2	3.4	1.35	5	2	
	placing concrete	78.58	m3		2	2.0	1.35	3	1	
	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	1,143.27	m2							

Table 3-2.9 Critical pass work (Ibrahimia) (4/5)

Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
control house		1	lot			160	1	160	-	0
riverbed protection	concrete block	494	pcs	5	2	49.4	1.35	67	-	0
	riprup	1,998.00	m2	58.8	1	34	1.35	46	-	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal for steel sheet pile									
	Ⅳw-type （driving L less 12m）	712	pcs	40	1	17.8	1.35	24	24	33
	Ⅲw-type （driving L less 15m）		pcs	43	1	0.0	1.35	0	-	
	tie-rod	1	lot						2	
	removal for inside coffer dam soil	14,620	m3	300	2	24.4	1.35	33	7	
removal for ex. structure	removal for outside of coffer dam	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	28,300.00	m3	350	2	40.4	1.35	55	55	20
	Gabion	800.00	pcs	4	5	40.0	1.35	54	54	54
	driving sheet pile outside coffer dam Type-F									
	Ⅳw-type （driving L less 23m） L=18.0m	121	pcs	9	1	13.4	1.35	18	3.5	
	Ⅲw-type（driving L less 6m） L=6.0m	104	pcs	39	1	2.7	1.35	4	2.5	
	capping concrete for steel sheet pile	1	lot			38	1.35	51	25.5	
		1	lot			30	1.35	41	-	
	curing	1	lot			5	1	5	-	
	driving sheet pile outside coffer dam Type-G									
	Ⅳw type （driving L less 12m） L=10.0m	5	pcs	28	1	0.2	1.35	0	3.5	
	Ⅲw type （driving L less 6m） L=5.0m		pcs	35	1	0.0	1.35	0		
	capping concrete for steel sheet pile	1	lot			38	1.35	51	25.5	
		1	lot			30	1.35	41	-	
	curing	1	lot			5	1	5	-	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
appurtenant work	embankment for left bank & road work	2,469.03	m3	250	2	4.9	1.35	7	7	
	curbstone work	164.84	m	22.5	2	3.7	1.35	5	5	
	base course t=20cm	583.65	m2	1,110	1	0.5	1.35	1	1	
	sub-base courset=20cm	583.65	m2	1,110	1	0.5	1.35	1	1	

Table 3-2.10 Critical pass work (Ibrahimia) (5/5)

	paving(surface) t=5cm	4,075.00	m2	2,300	1	1.8	1.35	2	2	18
	paving(sublayer) t=6cm	4,075.00	m2	2,300	1	1.8	1.35	2	2	
	Footpath								0	
	base course t=15cm	82.42	m2	268	1	0.3	1.35	0	0	
	paving(surface) t=5cm	82.42	m2	940	1	0.1	1.35	0	0	
trial operation	Trial operation･operation training					30	1	30	30	30
temporary work	removal for temporary platform									0
inside of Coffer dam	removal H-beam （driving L less 6m）L=14.5	24	pcs	39	1	0.6	1.35	1		
	removal H-beam （driving L less 16m）L=21.5	124	pcs	22	1	5.6	1.35	8		
	removal for platform	215.5	t	8.3	1	26.0	1.35	35		
	removal for steel top deck	1,296	m2	111	1	11.7	1.35	16		
cleaning･handover						22	1.35	30	15	15
				Critical pass days=			**765**	**days**		765
				Critical pass month=			**25.5**	**months ≒**	**25.5months**	25.5

(2) small regulators

The number of days for each work item is shown from Table 3-2.11 to 3-2.24. The construction period is:

- Badraman: 9 months
- Diroutiah: 10 months
- Abo Gabal: 11 months
- Sahelyia: 10 months

Table 3-2.11 Number of days for work item (Badraman) (1/4)

Badraman

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Preparation		1	lot					3	3	3
Temporary closure	Embankment（upstream）	1,768.20	m3	190	1	9.3	1.35	13	13	13
	Embankment（downstream）	802.20	m3	190	1	4.2	1.35	6	6	6
	sheet pile（single upstream) drivung L less 12m L-10m PU-28+1	46	pcs	20	1	2.3	1.35	3	3	9
	sheet pile（double downstream） drivung L less 9m L＝8m	53	pcs	25	1	2.1	1.35	3	3	
	support Hbeam for diversion canal driving L less 6m L=5m	17	pcs	31	1	0.5	1.35	1	1	
	sheet pilefor diversion canal drivung L less 9m L＝8m	34	pcs	25	1	1.4	1.35	2	2	
	support Hbeam for diversion canal driving L less 6m L=5m	12	pcs	31	1	0.4	1.35	1	1	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	500	m3	190	1	2.6	1.35	4	4	9
	curing	1	lot					5	5	
earth work	preparation								3	24
	excavation inside coffer dam	1,030	m3	190	1	5.4	1.35	7	7	
	embankment at left bank inside coffer dam	160	m3	300	1	0.5	1.35	1	1	
	embankment at right bank inside coffer dam	180	m3	300	1	0.6	1.35	1	1	
	back fill	710	m3	190	1	3.7	1.35	5	5	
	earth foundation grading	500	m2	100	1	5.0	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	Ⅳw （driving L less 2m）L-2m PU-12 upstream	14	pcs	55	1	0.3	1.35	0	0	1
	Ⅳw （driving L less 2m）L-2m PU-12 downstream	14	pcs	55	1	0.3	1.35	0	0	
	Ⅱw （driving L less 4m）L=10m PU-18	2	pcs	42	1	0.0	1.35	0	0	
	Ⅳw （driving L less 4m）L-8.0m PU-12	2	pcs	45	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	154.6	m3	38.6	1	4.0	1.35	5	5	95
	base									
	scaffolding	111.6	m2	71	1	1.6	1.35	2	2	
	re-bar	31.07	t	3.3	1	9.4	1.35	13	13	
	formwork	160.14	m2	30	1	5.3	1.35	7	4	
	placing concrete	345.17	m3	86	1	4.0	1.35	5	-	
	pier									
	scaffolding	634.00	m2	71	1	8.9	1.35	12	4	

Table 3-2.12 Number of days for work item (Badraman) (2/4)

	re-bar	24.45	t	3.3	1	7.4	1.35	10	10	
	formwork	559.62	m2	30	2	9.3	1.35	13	4	
	placing concrete	271.68	m3	45	1	6.0	1.35	8	1	
	other concrete(support bridge etc)									
	support		m3							
	re-bar	11.08	t	3.3	1	3.4	1.35	5	5	
	formwork	313.20	m2	30	2	5.2	1.35	7	2	
	placing concrete	123.11	m3	30	1	4.1	1.35	6	1	
	curing	1.00	lot							
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	45.8	m3	71	1	0.6	1.35	1	1	
	re-bar	0.7	t	3.3	1	0.2	1.35	0	0	
	formwork	32.0	m2	30	1	1.1	1.35	1	1	
	placing concrete	7.6	m3	7.6	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	42.7	m2	71	1	0.6	1.35	1	1	
	support	298.00	m3	71	1	4.2	1.35	6	3	
	re-bar	5.0	t	3.3	1	1.5	1.35	2	2	
	formwork	71.4	m2	30	1	2.4	1.35	3	4	
	placing concrete	34.1	m3	17	1	2.0	1.35	3	1	
	curing	1	lot			14	1	14	14	
	removal of form･support	412.10	m3	71	6	1.0	1.35	1	1	
Gate facility work	**groove**	1	lot			30.0	1	30		
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	26
	installation	1	lot			4	1.35	5	5	
concrete work	**upper pier**									
	scaffolding	103	m2	71	1	1.4	1.35	2	2	
	re-bar	1.25	t	3.3	1	0.4	1.35	1	1	
	formwork	57.33	m2	30	1	1.9	1.35	3	3	
	placing concrete	13.86	m3		2	2.0	1.35	3	1	

Table 3-2.13 Number of days for work item (Badraman) (3/4)

	platform for operation									12
	suppoort	75.16	m3	71	1	1.1	1.35	1	2	
	re-bar	0.85	t	3.3	1	0.3	1.35	0	1	
	formwork	24.20	m2	30	1	0.8	1.35	1	1	
	placing concrete	9.45	m3	9.45	1	1.0	1.35	1	1	
	curing	1	lot					14	14	
	removal for form, scaffolding & support	99.36	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									26
	assemble	1	lot			15	1.35	20	20	
	installation	1	lot			4	1.35	5	5	
		1	lot			160	1	160	-	0
riverbed protection stone riprap										
	foundation gravel	210	m2	155	1	1.4	1.35	2	2	6
	surface leveling	210.00	m2	89	1	2.4	1.35	3	3	
	stone setting	84	m3	129	1	0.7	1.35	1	1	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal of sheet pile									16
	sheet pile (single upstream) drivung L less 12m L-10m PU-28+1	46	pcs	40	1	1.2	1.35	2	2	
	sheet pile（double downstream） drivung L less 9m L＝8m	53	pcs	46	1	1.2	1.35	2	2	
	support Hbeam for diversion canal driving L less 6m L=5m	17	pcs	68	1	0.3	1.35	0	0	
	sheet pilefor diversion canal drivung L less 9m L＝8m	34	pcs	46	1	0.7	1.35	1	1	
	support Hbeam for diversion canal driving L less 6m L=5m	12	pcs	68	1	0.2	1.35	0	0	
	removal of embankment	2,570	m3	300	1	8.6	1.35	12	12	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	340	m3	190	1	1.8	1.35	2	2	2
	Driving sheet pile inside dam Type-F									
	Ⅳw （driing L less 9m） L=10m PU18	11	pcs	29	1	0.4	1.35	1	1	1
	Ⅲw （driing L less 9m） L=8m PU12	6	pcs	33	1	0.2	1.35	0	0	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
appurtenant work	embankment for left bank & road work	371.34	m3	250	1	1.5	1.35	2	2	
	curbstone work	205.44	m	22.5	1	9.1	1.35	12	12	
	base course t=20cm	853.38	m2	1,110	1	0.8	1.35	1	1	

Table 3-2.14 Number of days for work item (Badraman) (4/4)

	sub-base courset=20cm	853.38	m2	1,110	1	0.8	1.35	1	1	17
	paving（surface）t=5cm	853.38	m2	2,300	1	0.4	1.35	0	0	
	paving（sublayer）t=6cm								0	
	base course t=15cm	103.03	m2	268	1	0.4	1.35	1	1	
	paving（surface) t=5cm	103.03	m2	940	1	0.1	1.35	0	0	
commissioning･inspection	commissioning･operation training					15	1	15	15	15
	removal of soil inside dam		m3	300	1	0.0	1.35	0		
cleaning･handover						7	1.35	9		0
				Critical pass days=			**277**	**days**		277
				Critical pass month=			**9.2**	**months ≒**	**9 months**	9.2

Table 3-2.15 Number of days for work item (Diroutiah) (1/4)

Diroutiah

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Temporary closure	Embankment（upstream）	1,768.20	m3	190	1	9.3	1.35	13	13	27
	Embankment（downstream）	802.20	m3	190	1	4.2	1.35	6	6	
	sheet pile（single upstream）drivung L less 12m L-10m PU-28+1	46	pcs	20	1	2.3	1.35	3	3	
	sheet pile（double downstream） drivung L less 9m Ｌ＝8ｍ	53	pcs	25	1	2.1	1.35	3	3	
	support Ｈbeam for diversion canal driving L less 6m L=5m	17	pcs	31	1	0.5	1.35	1	1	
	sheet pilefor diversion canal drivung L less 9m Ｌ＝8ｍ	34	pcs	25	1	1.4	1.35	2	2	
	support Ｈbeam for diversion canal driving L less 6m L=5m	12	pcs	31	1	0.4	1.35	1	1	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	650	ｍ3	190	1	3.4	1.35	5	5	10
	curing	1	lot					5	5	
earth work	preparation								3	24
	excavation inside coffer dam	1,140.00	m3	190	1	6.0	1.35	8	8	
	embankment at left bank inside coffer dam	100.00	m3	300	1	0.3	1.35	0	0	
	embankment at right bank inside coffer dam	230.00	m3	300	1	0.8	1.35	1	1	
	back fill	600.00	m3	190	1	3.2	1.35	4	4	
	earth foundation grading	500	ｍ2	100	1	5.0	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	Ⅳw （driving L less 2m）L-2ｍ PU-12 upstream	19	pcs	55	1	0.3	1.35	0	0	1
	Ⅳw （driving L less 2m）L-2ｍ PU-12 downstream	19	pcs	55	1	0.3	1.35	0	0	
	Ⅱw （driving L less 4m）L=10m PU-12	2	pcs	45	1	0.0	1.35	0	0	
	Ⅳw （driving L less 4m）L-8.0m PU-12	2	pcs	45	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	24.28	m3	12	1	2.0	1.35	3	3	108
	base									
	scaffolding	119.1	m2	71	1	1.7	1.35	2	2	
	re-bar	43.07	t	3.3	1	13.1	1.35	18	18	
	formwork	182.92	m2	30	1	6.1	1.35	8	4	
	placing concrete	478.61	m3	86	1	5.6	1.35	8	-	
	pier									
	scaffolding	699.66	m2	71	1	9.9	1.35	13	4	
	re-bar	28.09	t	3.3	1	8.5	1.35	11	11	

Table 3-2.16 Number of days for work item (Diroutiah) (2/4)

	formwork	632.26	m2	30	1	21.1	1.35	28	8	
	placing concrete	312.09	m3	45	1	6.9	1.35	9	1	
	other concrete(support bridge etc)									
	re-bar	14.00	t	3.3	1	4.2	1.35	6	6	
	formwork	382.90	m2	30	2	6.4	1.35	9	2	
	placing concrete	155.56	m3	20	1	7.8	1.35	11	1	
	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	61.5	m3	71	1	0.9	1.35	1	1	
	re-bar	1.0	t	3.3	1	0.3	1.35	0	0	
	formwork	48.0	m2	30	1	1.6	1.35	2	2	
	placing concrete	11.5	m3	48	1	0.2	1.35	0	0	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	42.7	m2	71	1	0.6	1.35	1	1	
	support	424	m3	71	1	6.0	1.35	8	3	
	re-bar	7.4	t	3.3	1	2.2	1.35	3	3	
	formwork	106	m2	30	1	3.5	1.35	5	5	
	placing concrete	51.2	m3	24	1	2.1	1.35	3	3	
	curing	1	lot			14	1	14	14	
	removal of form･support	572.70	m3	71	6	1.3	1.35	2	2	
Gate facility work	**groove**	1	lot			30.0	1	30		26
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	
	installation	1	lot			4	1.35	5	5	
concrete work	**upper pier**									12
	scaffolding	114.57	m2	71	1	1.6	1.35	2	2	
	re-bar	1.48	t	3.3	1	0.4	1.35	1	1	
	formwork	70.11	m2	30	1	2.3	1.35	3	2	
	placing concrete	16.39	m3		2	2.0	1.35	3	1	
	platform for operation									
	suppoort	101.13	m3	71	2	0.7	1.35	1	2	

Table 3-2.17 Number of days for work item (Diroutiah) (3/4)

	re-bar	1.22	t	3.3	1	0.4	1.35	0	1	
	formwork	33.95	m2	30	2	0.6	1.35	1	2	
	placing concrete	13.50	m3		1	2.0	1.35	3	1	
	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	135.08	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									26
	assemble	1	lot			15	1.35	20	20	
	installation	1	lot			4	1.35	5	5	
		1	lot			160	1	160	-	0
riverbed protection stone riprap										
	foundation gravel	240	m2	155	1	1.5	1.35	2	2	7
	surface leveling	240.00	m2	89	1	2.7	1.35	4	4	
	stone setting	96	m3	129	1	0.7	1.35	1	1	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal of sheet pile									16
	sheet pile（single upstream）drivung L less 12m L-10m PU-28+1	46	pcs	40	1	1.2	1.35	2	2	
	sheet pile（double downstream） drivung L less 9m Ｌ＝8ｍ	53	pcs	46	1	1.2	1.35	2	2	
	support Ｈbeam for diversion canal driving L less 6m L=5m	17	pcs	68	1	0.3	1.35	0	0	
	sheet pilefor diversion canal drivung L less 9m Ｌ＝8ｍ	34	pcs	46	1	0.7	1.35	1	1	
	support Ｈbeam for diversion canal driving L less 6m L=5m	12	pcs	68	1	0.176471	1.35	0	0	
	removal of embankment	2,570	m3	300	1	8.6	1.35	12	12	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection	embankment	330.00	m3	190	1	1.7	1.35	2	2	2
	Driving sheet pile inside dam Type-F									
	Ⅳw （driing L less 9m） L=10m PU12	11	pcs	29	1	0.4	1.35	1	1	1
	Ⅲw （driing L less 9m） L=8m PU12	7	pcs	33	1	0.2	1.35	0	0	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9		
appurtenant work	embankment for left bank & road work	371.22	m3	250	1	1.5	1.35	2	2	21
	curbstone work	269.44	m	22.5	1	12.0	1.35	16	16	
	base course t=20cm	1,027.81	m2	1,110	1	0.9	1.35	1	1	
	sub-base courset=20cm	1,027.81	m2	1,110	1	0.9	1.35	1	1	
	paving（surface）t=5cm	1,027.81	m2	2,300	1	0.4	1.35	0	0	

Table 3-2.18 Number of days for work item (Diroutiah) (4/4)

	paving（sublayer）t=6cm								0	
	base course t=15cm	131.83	m2	268	1	0.5	1.35	1	1	
	paving（surface) t=5cm	131.83	m2	940	1	0.1	1.35	0		
commissioning･inspection	commissioning･operation training					15	1	15	15	15
	removal of soil inside dam		m3	300	1	0.0	1.35	0		
cleaning･handover						7	1.35	9		0
				Critical pass days=			**296**	**days**		296
				Critical pass month=			**9.9**	**months ≒**	**10 months**	9.9

Abo Gabal

Table 3-2.19 Number of days for work item (Abo Gabal) (1/3)

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Preparation		1	lot					3	3	3
Embankment for Access road		626.8	m3	300	1	2.1	1.35	3	3	3
Temporary coffer dam	driving sheet pile river side driving L less 6m L=10m	116	pcs	31	1	3.7	1.35	5	5	26
	driving sheet pile excavation side driving L less 6m L=10m	80	pcs	31	1	2.6	1.35	3	3	
	installation for tie-rod	1	lot			0.0	1.35	7	7	
	filling for inside double sheet	2,377.35	m3	300	1	7.9	1.35	11	11	
Temporary diversion canal	driving sheet pile river side driving L less 6m L=6m	92	pcs	31	1	3.0	1.35	4	4	17
	driving sheet pile excavation side driving L less 6m L=6m	75	pcs	31	1	2.4	1.35	3	3	
	waling・strut・jack	1	pcs			0.0	1.35	0	0	
	inside excavation	286.30	m3	4	10	7.2	1.35	10	10	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	600	m3	190	1	3.2	1.35	4	4	9
	curing	1	lot					5	5	
earth work	preparation								3	21
	excavation inside coffer dam	1,510.00	m3	190	1	7.9	1.35	11	11	
	embankment at left bank inside coffer dam		m3	300	1	0.0	1.35	0	0	
	embankment at right bank inside coffer dam		m3	300	1	0.0	1.35	0	0	
	back fill	550.00	m3	100	1	5.5	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	upstream driving L less 2m L=2m	24	pcs	55	1	0.4	1.35	1	1	1
	upstream driving L less 2m L=10m	2	pcs	55	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	18.81	m3	6	1	3.1	1.35	4	4	134
	base									
	scaffolding	119.1	m2	71	1	1.7	1.35	2	2	
	re-bar	58.30	t	3.3	1	17.7	1.35	24	24	
	formwork	173.54	m2	30	1	5.8	1.35	8	4	
	placing concrete	647.80	m3	130	1	5.0	1.35	7	-	
	pier									
	scaffolding	699.66	m2	71	1	9.9	1.35	13	4	
	re-bar	64.70	t	3.3	1	19.6	1.35	26	26	
	formwork	1,245.14	m2	30	2	20.8	1.35	28	8	
	placing concrete	718.92	m3	40	1	18.0	1.35	24	1	

Table 3-2.20 Number of days for work item (Abo Gabal) (2/3)

	other concrete(support bridge etc)									
	re-bar	0.00	t	3.3	2	0.0	1.35	0	0	
	formwork	0.00	m2	30	3	0.0	1.35	0	8	
	placing concrete	0.00	m3	20	1	0.0	1.35	0	1	
	curing									
	removal of form & support									
	passage									
	scaffolding	0	m2	71	1	0.0	1.35	0	0	
	support	61.2	m3	71	1	0.9	1.35	1	1	
	re-bar	0.7	t	3.3	1	0.2	1.35	0	0	
	formwork	32.0	m2	30	1	1.1	1.35	1	1	
	placing concrete	7.64	m3	7.64	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	1	5.5	1.35	7	7	
	support	221.00	m3	71	1	3.1	1.35	4	4	
	re-bar	3.2	t	3.3	1	1.0	1.35	1	1	
	formwork	68.1	m2	30	1	2.3	1.35	3	3	
	placing concrete	26.98	m3	26.98	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form･support	677.50	m3	71	6	1.6	1.35	2	2	
Gate facility work	**groove**	1	lot			30.0	1	30		
										28
	installation for Gate	1	lot			16	1.35	22	22	
	assemble									
	installation	1	lot			5	1.35	7	7	
concrete work	**upper pier**									12
	scaffolding	161.16	m2	71	1	2.3	1.35	3	2	
	re-bar	1.89	t	3.3	1	0.6	1.35	1	1	
	formwork	93.15	m2	30	1	3.1	1.35	4	2	
	placing concrete	21.05	m3		2	2.0	1.35	3	1	
	platform for operation									
	suppoort	195.47	m3	71	2	1.4	1.35	2	2	
	re-bar	1.76	t	3.3	1	0.5	1.35	1	1	
	formwork	48.90	m2	30	2	0.8	1.35	1	2	
	placing concrete	19.50	m3		2	2.0	1.35	3	1	

Table 3-2.21 Number of days for work item (Abo Gabal) (3/3)

	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	244.37	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									22
	assemble	1	lot			12	1.35	16	16	
	installation	1	lot			4	1.35	5	5	
		1	lot			160	1	160	-	0
			pcs	5	2	49.4	1.35	67	-	0
			m2	58.8	1	34	1.35	46	-	
temporary work	fire-flow inside cofferdam	1	lot			1	1	1	1	1
	removal for sheet pile for coffer dam									22
	river side driving L less 6m L=10m	116	pcs	54	1	2.1	1.35	3	3	
	excavation side driving L less 6m L=10m	80	pcs	54	1	1.5	1.35	2	2	
	tie-rod	1	lot						0	
	removal for inside soil	2,377.35	m3	190	1	12.5	1.35	17	17	
removal for diversion canal	river side driving L less 6m L=6m	92	pcs	54	1	1.7	1.35	2	2	14
	excavation side driving L less 6m L=6m	75	pcs	54	1	1.4	1.35	2	2	
	waling・strut・jack	1	lot							
	backfill	286	m3	4	10	7.2	1.35	10	10	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection work	Embankment	3,060.00	m3	350	2	4.4	1.35	6	6	6
	driving sheet pile Type-M									
	PU-12（driving L less 12m） L=10m front	75	pcs	28	1	2.7	1.35	4	4	6
	Ⅲw型 （driving L less 6m） L=6m back	72	pcs	39	1	1.8	1.35	2	2	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
commissioning・inspection	commissioning・operation training					15	1	15	15	15
cleaning・handover						22	1.35	30		0
				Critical pass days=			**334**	**days**		334
				Critical pass month=			**11.1**	**months ≒**	**11 months**	11.1

Sahelyia

Table 3-2.22 Number of days for work item (Sahelyia) (1/3)

Number of days for each work item

each work item	detail of each work	work quantity	unit	work volume a day	no.of party	working days	Working days coefficient	period of excecution	critical pass days	
Preparation		1	lot					3	3	3
Embankment for Access road		460	m3	300	1	1.5	1.35	2	2	2
Temporary coffer dam	driving sheet pile river side driving L less 6m L=10m	115	pcs	31	1	3.7	1.35	5	5	24
	driving sheet pile excavation side driving L less 6m L=10m	77	pcs	31	1	2.5	1.35	3	3	
	installation for tie-rod	1	lot					5	5	
	filling for inside double sheet	2,316.60	m3	300	1	7.7	1.35	10	10	
Temporary diversion canal	driving sheet pile river side driving L less 6m L=6m	76	pcs	31	1	2.5	1.35	3	3	18
	driving sheet pile excavation side driving L less 6m L=6m	89	pcs	31	1	2.9	1.35	4	4	
	waling・strut・jack	1	lot							
	inside excavation	307.30	m3	4	10	7.7	1.35	10	10	
embankment at right bank	temporary road for excavation									
Temporary work	hardening of soft soil	600	m3	190	1	3.2	1.35	4	4	9
	curing	1	lot					5	5	
earth work	preparation								3	17
	excavation inside coffer dam	1,010.00	m3	190	1	5.3	1.35	7	7	
	embankment at left bank inside coffer dam		m3	300	1	0.0	1.35	0	0	
	embankment at right bank inside coffer dam		m3	300	1	0.0	1.35	0	0	
	back fill	510.00	m3	100	1	5.1	1.35	7	7	
riverbed protection	driving cut-off sheet pile									
	upstream driving L less 2m L=2m	14	pcs	55	1	0.3	1.35	0	0	0
	upstream driving L less 2m L=12m	2	pcs	55	1	0.0	1.35	0	0	
concrete work	main structure lean concrete	15.61	m3	5.2	1	3.0	1.35	4	4	108
	base									
	scaffolding	119.1	m2	71	1	1.7	1.35	2	4	
	re-bar	25.97	t	3.3	1	7.9	1.35	11	11	
	formwork	121.94	m2	30	1	4.1	1.35	5	4	
	placing concrete	288.50	m3	58	1	5.0	1.35	7	-	
	pier									
	scaffolding	699.66	m2	71	1	9.9	1.35	13	4	
	re-bar	37.82	t	3.3	1	11.5	1.35	15	15	

Table 3-2.23 Number of days for work item (Sahelyia) (2/3)

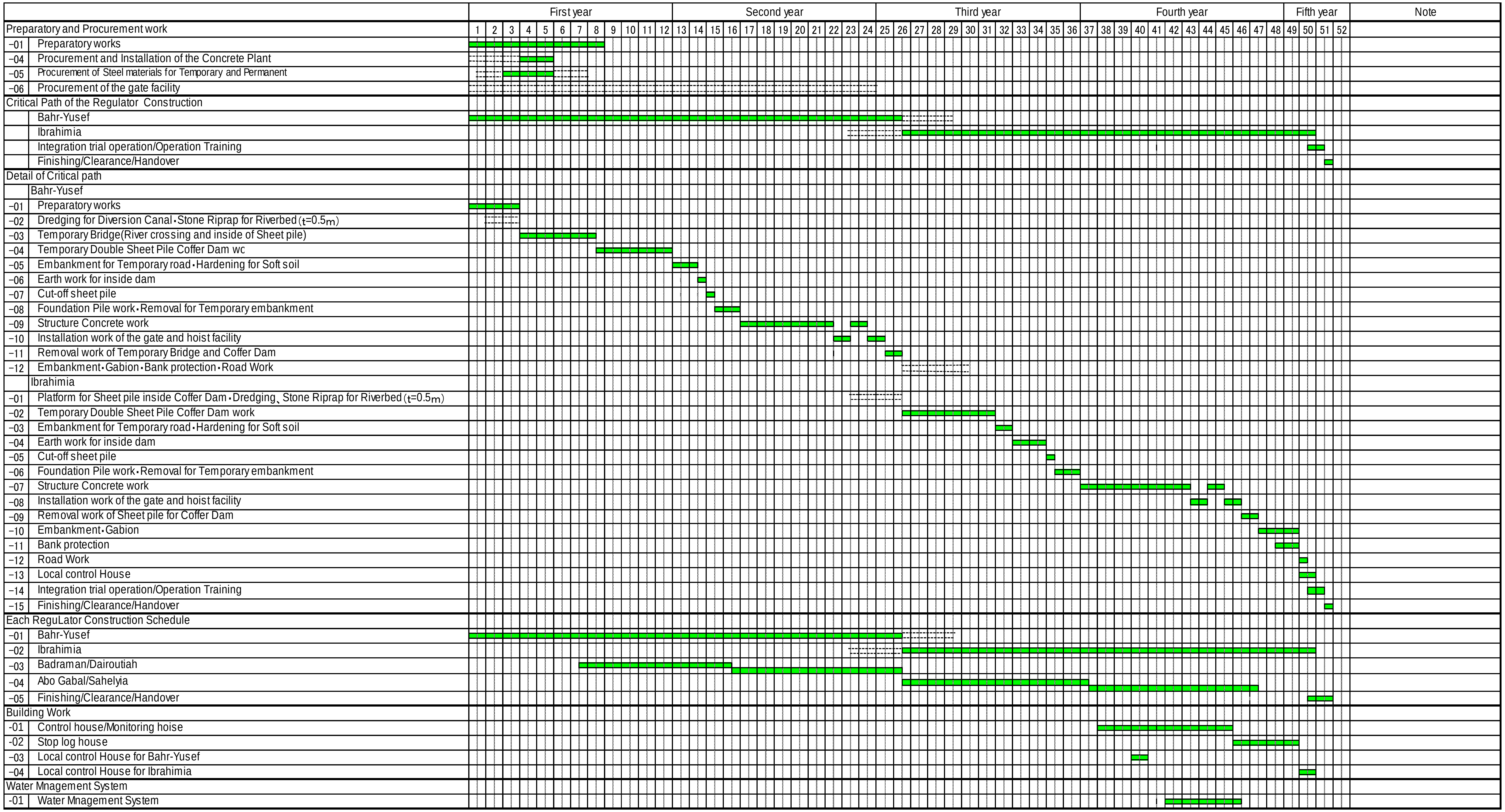
	formwork	795.16	m2	30	2	13.3	1.35	18	8	
	placing concrete	420.22	m3	23	1	18.3	1.35	25	1	
	other concrete(support bridge etc)									
	re-bar	0.00	t	3.3	2	0.0	1.35	0	0	
	formwork	0.00	m2	30	3	0.0	1.35	0	8	
	placing concrete	0.00	m3	20	1	0.0	1.35	0	1	
	curing									
	removal of form & support									
	passage									
	scaffolding		m2	71	1	0.0	1.35	0	0	
	support	37.8	m3	71	1	0.5	1.35	1	1	
	re-bar	0.3	t	3.3	1	0.1	1.35	0	0	
	formwork	16.0	m2	30	1	0.5	1.35	1	1	
	placing concrete	3.82	m3	3.82	1	1.0	1.35	1	1	
	curing	1	lot			14	1	14	14	
	removal of form & support	3,680.40	m3	71	6	8.6	1.35	12	-	
	maintenance bridge									
	scaffolding	388.4	m2	71	1	5.5	1.35	7	7	
	support	141.70	m3	71	1	2.0	1.35	3	3	
	re-bar	1.6	t	3.3	1	0.5	1.35	1	1	
	formwork	34.5	m2	30	1	1.2	1.35	2	2	
	placing concrete	13.53	m3	7	1	1.9	1.35	3	3	
	curing	1	lot			14	1	14	14	
	removal of form・support	564.60	m3	71	6	1.3	1.35	2	2	
Gate facility work	**groove**	1	lot			30.0	1	30		26
	installation for Gate									
	assemble	1	lot			15	1.35	20	20	
	installation	1	lot			4	1.35	5	5	
concrete work	**upper pier**									11
	scaffolding	131.04	m2	71	1	1.8	1.35	2	2	
	re-bar	1.42	t	3.3	1	0.4	1.35	1	1	
	formwork	65.61	m2	30	1	2.2	1.35	3	2	
	placing concrete	15.80	m3		2	2.0	1.35	3	1	
	platform for operation									
	suppoort	115.33	m3	71	1	1.6	1.35	2	2	
	re-bar	0.95	t	3.3	1	0.3	1.35	0	1	

Table 3-2.24 Number of days for work item (Sahelyia) (3/3)

	formwork	27.10	m2	30	1	0.9	1.35	1	1	
	placing concrete	10.50	m3	10.5	1	1.0	1.35	1	1	
	curing	1	lot	71	2			14		
	removal for form, scaffolding & support	142.43	m2							
Gate facility work	installation for groove	1	lot			40	1.35	54	-	0
	lifting gear assemble/installation/adjustment									26
	assemble	1	lot			15	1.35	20	20	
	installation	1	lot			4	1.35	5	5	
		1	lot							0
riverbed protection	concrete block		pcs	5	2	0.0	1.35	0	-	0
	riprup		m2	58.8	1	0.0	1.35	0	-	
temporary work	fire-flow inside cofferdam	1	lot				1	0	1	1
	removal for sheet pile for coffer dam									16
	river side driving L less 6m L=10m	115	pcs	54	1	2.1	1.35	3	3	
	excavation side driving L less 6m L=10m	77	pcs	54	1	1.4	1.35	2	-	
	tie-rod	1	lot						2	
	removal for inside soil	1,544	m3	190	1	8.1	1.35	11	11	
removal for diversion canal	river side driving L less 6m L=6m	76	pcs	54	1	1.4	1.35	2	2	14
	excavation side driving L less 6m L=6m	89	pcs	54	1	1.6	1.35	2	2	
	waling･strut･jack	1	lot							
	backfill	307.30	m3	4	10	7.7	1.35	10	10	
removal for ex. structure	all removal (inside coffer dam)	0	m3	63	1	0.0	1.35	0	0	
Bank protection work	Embankment	1,320.00	m3	350	2	1.9	1.35	3	3	3
	driving sheet pile Type-H									
	PU-12（driving L less 12m） L=10m front	32	pcs	28	1	1.1	1.35	2	4	
	Ⅲw型 （driving L less 6m） L=6m back	32	pcs	39	1	0.8	1.35	1	3	
Gate facility work	water level indicator setting/adjustment	1	lot			7	1.35	9	-	
commissioning･inspection	commissioning･operation training					15	1	15	15	15
cleaning･handover						22	1.35	30		0
				Critical pass days=			**287**	**days**		287
				Critical pass month=			**9.6**	**months ≒**	**10 months**	9.6

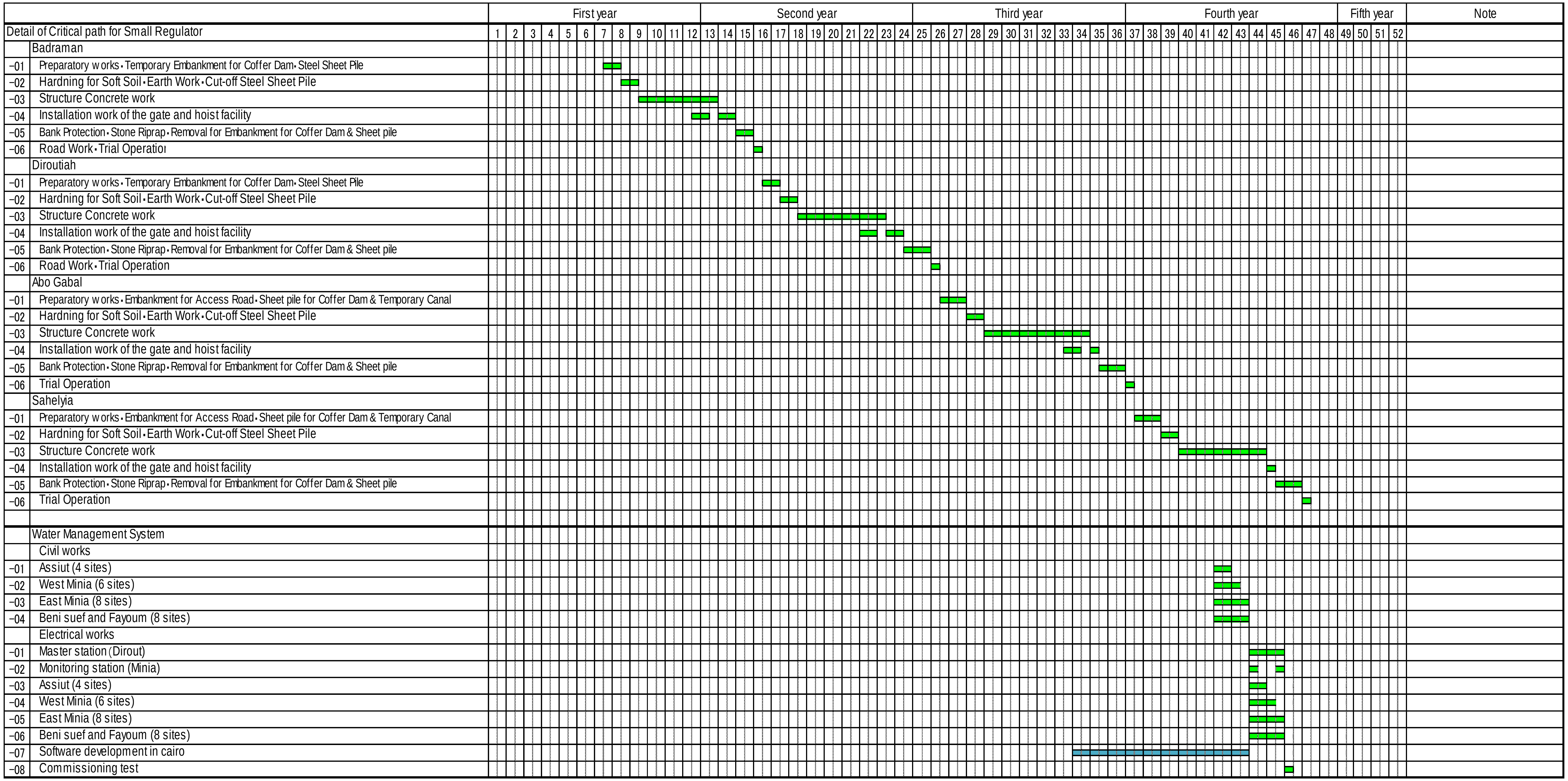
3-3 Construction schedule

Table 3-3.1 Construction schedule (large regulators)



		First year	Second year	Third year	Fourth year	Fifth year	Note
Preparatory and Procurement work		1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32 33 34 35 36	37 38 39 40 41 42 43 44 45 46 47 48	49 50 51 52	
−01	Preparatory works	🟩 1–8					
−04	Procurement and Installation of the Concrete Plant	┄ 1–3 🟩 4–5					
−05	Procurement of Steel materials for Temporary and Permanent	┄ 1–2 🟩 3–5 ┄ 6–7					
−06	Procurement of the gate facility	┄ 1–12	┄ 13–24				
Critical Path of the Regulator Construction							
	Bahr-Yusef	🟩 1–12	🟩 13–24	🟩 25–26 ┄ 26–29			
	Ibrahimia		┄ 23–24	┄ 25–26 🟩 26–36	🟩 37–48	🟩 49–50	
	Integration trial operation/Operation Training					🟩 50–51	
	Finishing/Clearance/Handover					🟩 51	
Detail of Critical path							
	Bahr-Yusef						
−01	Preparatory works	🟩 1–3					
−02	Dredging for Diversion Canal・Stone Riprap for Riverbed (t=0.5m)	┄ 2–3					
−03	Temporary Bridge(River crossing and inside of Sheet pile)	🟩 4–8					
−04	Temporary Double Sheet Pile Coffer Dam wc	🟩 8–12					
−05	Embankment for Temporary road・Hardening for Soft soil		🟩 13–14				
−06	Earth work for inside dam		🟩 14				
−07	Cut-off sheet pile		🟩 15				
−08	Foundation Pile work・Removal for Temporary embankment		🟩 15–16				
−09	Structure Concrete work		🟩 17–22 🟩 23–24				
−10	Installation work of the gate and hoist facility		🟩 22–23 🟩 24	🟩 25			
−11	Removal work of Temporary Bridge and Coffer Dam			🟩 25–26			
−12	Embankment・Gabion・Bank protection・Road Work			┄ 26–30			
	Ibrahimia						
−01	Platform for Sheet pile inside Coffer Dam・Dredging、Stone Riprap for Riverbed (t=0.5m)		┄ 23–24	┄ 25–26			
−02	Temporary Double Sheet Pile Coffer Dam work			🟩 26–31			
−03	Embankment for Temporary road・Hardening for Soft soil			🟩 32			
−04	Earth work for inside dam			🟩 33–34			
−05	Cut-off sheet pile			🟩 35			
−06	Foundation Pile work・Removal for Temporary embankment			🟩 35–36			
−07	Structure Concrete work				🟩 37–43 🟩 44–45		
−08	Installation work of the gate and hoist facility				🟩 43–44 🟩 45–46		
−09	Removal work of Sheet pile for Coffer Dam				🟩 46–47		
−10	Embankment・Gabion				🟩 47–48	🟩 49	
−11	Bank protection				🟩 48	🟩 49	
−12	Road Work					🟩 50	
−13	Local control House					🟩 50	
−14	Integration trial operation/Operation Training					🟩 50–51	
−15	Finishing/Clearance/Handover					🟩 51	
Each ReguLator Construction Schedule							
−01	Bahr-Yusef	🟩 1–12	🟩 13–24	🟩 25–26 ┄ 26–29			
−02	Ibrahimia		┄ 23–24	┄ 25–26 🟩 26–36	🟩 37–48	🟩 49–50	
−03	Badraman/Dairoutiah	🟩 7–12	🟩 13–16 🟩 16–24	🟩 25–26			
−04	Abo Gabal/Sahelyia			🟩 26–36	🟩 37 🟩 37–47		
−05	Finishing/Clearance/Handover					🟩 50–51	
Building Work							
-01	Control house/Monitoring hoise				🟩 38–45		
-02	Stop log house				🟩 46–48	🟩 49	
−03	Local control House for Bahr-Yusef				🟩 40–41		
−04	Local control House for Ibrahimia					🟩 50	
Water Mnagement System							
-01	Water Mnagement System				🟩 42–46		

Table 3-3.2 Construction schedule (small regulators)



		First year												Second year												Third year												Fourth year												Fifth year				Note
Detail of Critical path for Small Regulator		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
	Badraman																																																					
-01	Preparatory works・Temporary Embankment for Coffer Dam・Steel Sheet Pile							🟩	🟩																																													
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile								🟩	🟩																																												
-03	Structure Concrete work									🟩	🟩	🟩	🟩	🟩																																								
-04	Installation work of the gate and hoist facility												🟩	🟩	🟩																																							
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile															🟩																																						
-06	Road Work・Trial Operatio																🟩																																					
	Diroutiah																																																					
-01	Preparatory works・Temporary Embankment for Coffer Dam・Steel Sheet Pile																🟩	🟩																																				
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																	🟩	🟩																																			
-03	Structure Concrete work																		🟩	🟩	🟩	🟩	🟩	🟩																														
-04	Installation work of the gate and hoist facility																						🟩	🟩	🟩																													
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																								🟩	🟩																												
-06	Road Work・Trial Operation																										🟩																											
	Abo Gabal																																																					
-01	Preparatory works・Embankment for Access Road・Sheet pile for Coffer Dam & Temporary Canal																										🟩	🟩																										
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																												🟩																									
-03	Structure Concrete work																													🟩	🟩	🟩	🟩	🟩	🟩																			
-04	Installation work of the gate and hoist facility																																	🟩	🟩	🟩																		
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																			🟩	🟩																	
-06	Trial Operation																																					🟩																
	Sahelyia																																																					
-01	Preparatory works・Embankment for Access Road・Sheet pile for Coffer Dam & Temporary Canal																																					🟩	🟩															
-02	Hardning for Soft Soil・Earth Work・Cut-off Steel Sheet Pile																																							🟩														
-03	Structure Concrete work																																								🟩	🟩	🟩	🟩	🟩									
-04	Installation work of the gate and hoist facility																																													🟩								
-05	Bank Protection・Stone Riprap・Removal for Embankment for Coffer Dam & Sheet pile																																													🟩	🟩							
-06	Trial Operation																																															🟩						
	Water Management System																																																					
	Civil works																																																					
-01	Assiut (4 sites)																																										🟩											
-02	West Minia (6 sites)																																										🟩	🟩										
-03	East Minia (8 sites)																																										🟩	🟩										
-04	Beni suef and Fayoum (8 sites)																																										🟩	🟩										
	Electrical works																																																					
-01	Master station (Dirout)																																												🟩	🟩								
-02	Monitoring station (Minia)																																												🟩	🟩								
-03	Assiut (4 sites)																																												🟩									
-04	West Minia (6 sites)																																												🟩	🟩								
-05	East Minia (8 sites)																																												🟩	🟩								
-06	Beni suef and Fayoum (8 sites)																																												🟩	🟩								
-07	Software development in cairo																																		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦										
-08	Commissioning test																																														🟩							

4. Project Cost Estimation

4-1 Criteria and manual of project cost estimation

There are no official standards for construction cost estimation in Egypt. The project cost is estimated by using Japanese Standards articulated in *JICA’s Design & Estimation Manual, Estimate Standards* (hereinafter referred to as ‘Manual’).

(1) Time of cost estimation and expected commencement date

Time of cost estimation is January 2017. The commencement date is expected in February 2018 according to the memorandum signed on July 2015. The amount of price escalation from the time of cost estimation to the project completion date is included in the price contingency.

(2) Exchange rate

A fixed exchange rate system in the Egyptian market was shifted to a flexible exchange rate system on 3rd of November 2016. At the beginning of the trading, the US$-LE exchange rate was provisionally set at US$1 = LE13, a devaluation of approximately 48%. Also, a reduction of the fuel subsidy was made on 4th of November 2016, and the prices of gasoline, diesel oil, and butane gas were raised.

As of April 2017, the exchange rate system completely shifted to the flexible exchange rate. As a result, the value of LE was going down about half.

These changes in the economic policy of the Egyptian government were the conditions for receiving a loan from the IMF. The exchange rate and the prices will be affected by the policy for a while, and the unstable situation with Egyptian market is predicted to continue.

In order to reflect such social context to the detail cost estimation, exchange rate was applied as the average rate for the three months from February to April 2017, and the risk due to the rapid price increase and unstable exchange rate after November 2016 is covered by the consideration of the price contingency.

As a result, the exchange rate is calculated as follows;

1USD = ¥113.34, 1EUR = ¥121.26, 1LE = ¥6.49

(3) Working days coefficient

1.35 of the ratio was applied to the working days coefficient.

(4) Indirect cost

The ratio of indirect cost was applied based on the cost calculations in the Minutes of Discussions (May 2014).

- Indirect cost for Civil and Temporary Works : 35% of each direct cost
- Indirect cost for Gate Manufacture : 3% of the direct cost

(5) Unit price of manpower, materials, and rental fee of heavy equipment etc.

- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. which are from Japan, the unit price was applied as 90% of the average price between two books for monthly unit price published in Japan. When there was any item not described on the two books, competitive estimations from three companies were applied.
- Labor fee for public work in Tokyo is applied to the unit price of Japanese skilled labor.
- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. in Egypt, 100% of the average price of the competitive estimations from three companies was applied.

(6) Price escalation

The price escalation rate in the target country is calculated using the economic growth rate of the world economy and the predicted value of inflation rate set by the IMF.

However, because the avobe calculation method of the price escalation rate is not considered the recent rapid price increase, it is not reflected in reality. Therefore, the recent price escalation was reflected by additional calculation applying a monthly inflation rate issued by the Central Bank of Egypt.

- Price escalation rate for LC :
  total ratio is 18.9% (17.2% of recent price escalation + 1.0% per year during construction)
- Price escalation rate for FC :
  total ratio is 4.2% (1.6% per year during construction)

(7) Depreciation ratio for temporary steel material

Steel material for temporary works has a remaind value even after the completion of the construction. The depreciation ratio for temporary steel material was applied 50% according to the Egyptian law.

4-2 Estimation of the project cost

Project cost estimation was carried out based on final design and quauntity which was discussed after submitting the B/D report.

According to the discussion on the B/D cost estimation, the procurement of steel material was changed from Japan to a third country in Europe, and small scale gates and stoplogs were also changed to be procured in Egypt.

The changing points on the design of regulators from the B/D stage are as follows:

(1) Foundation work: from steel sheet pile to cast-in-place RC pile

(2) Bank protection: embankment and gabion protection were newly added at downstream of the left bank of the Bahr Yusef canal and the right bank of the Ibrahimia canals

(3) Dewatering method: from deepwell method to well-point method

The construction and project cost calculated by the above conditions are as follows. It is the approved cost in the 28th TAC meeting on 26th April 2017, and the updated cost of Integrated Water Management System needs to refer to “Volume II Water Management System”.

Table 4-2.1 Construction and project cost estimation

Item	Unit	Quantity	Amount			Total (Exchange to "YEN")
			US$	LE	YEN	
I Construction Cost	**L.S**	**1**	**6,138,654**	**377,480,579**	**2,219,659,487**	**5,365,263,000**
(breakdown)						
A. Civil Works	L.S	1	1,422,252	213,048,447	1,870,904,765	3,414,787,000
B. Temporary works	L.S	1	4,309,402	117,144,168	348,754,722	1,597,447,000
C. Building works	L.S	1		4,589,565		29,786,000
D. Integrated Water Management System	L.S	1		42,698,399		277,112,000
E. Dispute Board	L.S	1	407,000			46,129,000
II Consultant Service	**L.S**	**1**		**17,131,288**	**277,426,230**	**388,607,000**
III Contingency for Construction	**L.S**	**1**	**577,647**	**93,785,050**	**208,869,958**	**883,006,000**
(breakdown)						
Price Contingency	L.S	1	257,823	71,343,829	93,225,698	585,469,000
Physical Contingency	L.S	1	319,824	22,441,220	115,644,259	297,537,000
IV Contingency for Consultant Service	**L.S**	**1**		**4,256,269**	**26,105,808**	**53,729,000**
(break down)						
Price Contingency	L.S	1		3,237,813	11,651,902	32,665,000
Physical Contingency	L.S	1		1,018,455	14,453,907	21,064,000
V Interest During Construction	**L.S**	**1**			**20,100,000**	**20,100,000**
Project Cost (I～V)			**6,716,301**	**492,653,185**	**2,752,161,483**	**6,710,705,000**
VI Other Cost Estimation	**L.S**	**1**		**94,821,619**		**615,391,000**
(breakdown)						
Administration Cost	L.S	1		25,850,173		167,767,000
VAT	L.S	1		68,971,446		447,624,000
Front-end Fee	L.S	1		-		-
Total Project Cost (I～VI)			**6,716,301**	**587,474,805**	**2,752,161,483**	**7,326,096,000**

This project is aimed at STEP (Special Terms for Economic Partnership) of Japanese ODA Loans. The following items are mainly expected to be applied in this project;

- Steel double-sheet pile method
- overflow double-leaf gate to regulators

Ratio of the goods and services to be procured from Japan (“the Ratio”) is shown in Table 4-2.2.

Table 4-2.2 Ratio for STEP loan

Item	Grade	Detail	Unit	Quantity	Amount
A-11. Gate manufactures and works					
1. Gate manufacture	gate leaf	6.0×6.55	L.S	2.0	324,769,300
	gate guide		L.S	2.0	272,305,220
	hoisting device	hydraulic	L.S	2.0	846,320,100
	remote operation system		L.S	2.0	228,439,580
1. Installation for manufactures	Japanese mechanical engineer		day	1,050.0	31,403,295
	Japanese electrical engineer fo		day	1,050.0	35,009,415
sub-total					1,738,246,910
A-12. Expense of the machine and facilities					
1. Rent fee for heavy equipment	2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0	42,926,895
sub-total					42,926,895
B-1. Temporary Coffer Dam					
1. Double sheet pile	14). Japanese sheet pile opera		day	2,190.0	79,914,195
sub-total					79,914,195
B-8. Transportation / Shipment					
	B-8-13. packing	951.0 F/T	L.S	1.0	12,754,883
	B-8-14. loading		L.S	1.0	7,095,825
	B-8-15. ocean transpotation		F/T	951.0	26,190,947
sub-total					46,041,655
Total					1,907,129,655

Ratio of the goods and services to be procured from Japan

1) Construction Cost	5,365,263	10^3 YEN
2) Cost of the goods and services to be procured from Japan	1,907,130	10^3 YEN
2)／1)＝	35.5%	＞30%

Table 4-2.3 Summary of the project cost estimation

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

Exchange Rate	1USD= 113.34 (YEN)
	1EUR= 121.26 (YEN)
	1LE= 6.49 (YEN)

Item				Unit	Quantity	Amount			Total (Exchange to YEN)	Remarks
						US$	LE	YEN		
I Construction Cost	I-1 Direct Cost	A. Civil Works	A-1. Excavation	L.S	1.0		4,438,016.50		28,802,000	
			A-2. Embankment	L.S	1.0		18,815,688.70		122,113,000	
			A-3. Demolition work	L.S	1.0		131,996.64		856,000	
			A-4. Sheet pile bank protection	L.S	1.0	636,160.04	5,394,080.56	6,996,465	114,106,000	
			A-5. Bank protection	L.S	1.0		5,023,275.06	10,700,560	43,301,000	
			A-6. Canal bed protection	L.S	1.0	196,050.69	2,641,631.39		39,364,000	
			A-7. Concrete work for regulators	L.S	1.0		44,873,249.71	686,206	291,913,000	
			A-8. Pile foundation work	L.S	1.0		13,382,883.34		86,854,000	
			A-9. Accessory works	L.S	1.0		19,516,170.59	17,569,265	144,229,000	
			A-10. Electric works	L.S	1.0		3,626,535.45	8,650,000	32,186,000	
			A-11. Gate manufactures and works	L.S	1.0		19,081,522.83	1,672,334,600	1,796,173,000	
			A-12. Expense of the machine and facilities	L.S	1.0	221,309.66	23,815,178.13	53,661,990	233,305,000	
		sub total (A. Civil works)				1,053,520.39	160,740,228.90	1,770,599,086	2,933,209,000	
		B. Temporary Works	B-1. Temporary Coffer Dam	L.S	1.0	840,284.40	19,099,569.97	110,691,135	329,885,000	
			B-2. Single Sheet Pile	L.S	1.0	438,170.24	2,790,300.38	6,347,427	74,118,000	
			B-3. Temporary bridge	L.S	1.0		4,976,786.73	53,423,642	85,722,000	
			B-4. Dewatering	L.S	1.0		10,519,709.00		68,272,000	
			B-5. Temporary road & preparation	L.S	1.0		7,783,260.59		50,513,000	
			B-6. diversion works	L.S	1.0		11,759,640.95		76,320,000	
			B-7. Other temporary works	L.S	1.0		18,178,115.27	17,112,000	135,087,000	
			B-8. Transpotation / Shipment	L.S	1.0	1,913,684.57	13,325,895.23	75,199,059	378,581,000	
		sub total (B. Temporary works)				3,192,139.21	88,433,278.12	262,773,263	1,198,502,000	
		C. Building Works	C-1. Control house	L.S	1.0		1,977,700.00		12,835,000	
			C-2. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-3. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-4. Stop log room	L.S	1.0		818,200.00		5,310,000	
		sub total (C. Building works)					3,399,700.00		22,064,000	
		D. Integrated Water Management System	D-1. IWMS manufactures	L.S	1.0		15,676,546.12		101,740,000	
			D-2. Installation for IWMS	L.S	1.0		15,951,897.71		103,527,000	
		sub total (D. Integrated Water Management System)					31,628,443.83		205,268,000	
		E. Dispute Board	E-1. Dispute Board	L.S	1.0	407,000.00			46,129,000	
		sub total (E. Dispute Board)				407,000.00			46,129,000	
						4,652,659.60	284,201,650.85	2,033,372,349	4,405,173,000	
	I-2 Indirect Cost					1,485,994.40	93,278,928.15	186,287,138	960,089,000	
						6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,000**	
						13.0%	45.7%	41.3%		
II Consultant Service	Remuneration			L.S	1.0		10,092,110.00	230,823,000	296,320,000	
	Direct Expense			L.S	1.0		7,039,178.00	46,603,230	92,287,000	
							17,131,288.00	277,426,230	**388,607,000**	
III Contingency for Construction	Price Contingency		LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		71,343,829.43		**463,021,000**	
			FC: 1.6%/year, total ratio is 4.2%	L.S	1.0	257,823.47		93,225,698	**122,448,000**	
	Physical Contingency			%	5.0	319,823.87	22,441,220.42	115,644,259	**297,537,000**	
IV Contingency for Consultant Service	Price Contingency		LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		3,237,813.43		**21,013,000**	
			FC: 1.6%/year, total ratio is 4.2%	L.S	1.0			11,651,902	**11,652,000**	
	Physical Contingency			%	5.0		1,018,455.07	14,453,907	**21,064,000**	
V Interest During Construction	0.01 %/year			L.S	1.0			20,100,000	**20,100,000**	

Total Construction Cost (I～V)	6,716,301.34	492,653,185.36	2,752,161,483	**6,710,705,000**	
	11.3%	47.6%	41.1%		

Table 4-2.4 Bill of quantities (1/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
I Construction Cost										6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,489**	
I-1 Direct Cost										4,652,659.60	284,201,650.85	2,033,372,349	**4,405,173,502**	
A. Civil Works										1,053,520.39	160,740,228.90	1,770,599,086	**2,933,209,173**	
A-1. Excavation	A-1-1. Excavation	1. excavation	1). excavation and loading	0.8m3 back hoe	m3	23,390.0		19.82			463,589.80		3,008,698	
			2). excavation for concrete basement	0.8m3 back hoe	m3	1,320.0		28.32			37,382.40		242,612	
		sum									500,972.20		3,251,310	
		2. excavated soil disposal	1). excavated soil disposal	Distance 20km	m3	24,710.0		159.33			3,937,044.30		25,551,418	
total											4,438,016.50		28,802,727	
A-2. Embankment	A-2-1. Embankment	1. Embankment	1). backfill 1	15t bulldozer	m3	76,490.0		37.90			2,898,971.00		18,814,322	
			2). backfill 2	vibration roller,tamping machine	m3	7,470.0		45.37			338,913.90		2,199,551	
			3). material fee for backfill	sand	m3	60,873.0		67.10			4,084,578.30		26,508,913	
		sum									7,322,463.20		47,522,786	
		2. transportation fee for buying material	1). excavation and loading	0.8m3 back hoe loose soil	m3	60,873.0		19.22			1,169,979.06		7,593,164	
			2). transportation by damp truck	Distance 20km	m3	60,873.0		135.51			8,248,900.23		53,535,362	
		sum									9,418,879.29		61,128,527	
		3. transportation fee for reused material	1). excavation and loading	0.8m3 back hoe loose soil	m3	45,183.0		19.22			868,417.26		5,636,028	
			2). transportation by damp truck	Distance 0.3km	m3	45,183.0		18.47			834,530.01		5,416,100	
		sum									1,702,947.27		11,052,128	
		4. Earth finishing	1). earth finishing foundation		m3	4,640.0		7.36			34,150.40		221,636	
			2). rough finishing	0.8m3 back hoe	m2	1,610.0		34.70			55,867.00		362,577	
		sum									90,017.40		584,213	
		5. protection fence for waterpollution	1). protection fence		m	253.0		1,112.18			281,381.54		1,826,166	
total											18,815,688.70		122,113,820	
A-3. Demolition work	A-3-1. Demolition work	1. Demolition work	1). concrete demolition	reinforced concrete	m3	195.4		469.06			91,663.70		594,897	
			2). concrete demolition	plain concrete	m3	5.8		224.59			1,298.13		8,425	
			3). breaked concrete disposal	Distance 20km	m3	201.2		194.01			39,034.81		253,336	
total											131,996.64		856,658	
A-4. Sheet pile bank protection	A-4-1. Capping concrete	1. crown works	1). formwork	reinforced concrete	m2	1,663.9		400.74			666,791.28		4,327,475	
			2). placing reinforced concrete	25N/mm2 by crane	m3	517.9		1,356.29			702,409.02		4,558,635	
			3). curing	reinforced concrete	m3	517.9		7.83			4,055.07		26,317	
			4). bending,cutting and placing for re-bar	D12	t	13.6		18,857.16			256,777.94		1,666,489	
			5). joint filler	@10m	m2	53.5		403.70			21,614.09		140,275	
	sub total										1,651,647.40		10,719,192	
	A-4-2. Sheet pile	1. Sheet pile protection	1). driving sheet pile	PU18, L≦15m (driving length)	sheet	126.0		1,466.45			184,772.70		1,199,175	
				PU18, L≦12m (driving length)	sheet	146.0		1,231.17			179,750.82		1,166,583	
				PU18, L≦9m (driving length)	sheet	43.0		997.84			42,907.12		278,467	
				PU12, L≦12m (driving length)	sheet			1,055.19						
				PU12, L≦9m (driving length)	sheet	62.0		880.52			54,592.24		354,304	
				PU12, L≦6m (driving length)	sheet	486.0		761.90			370,283.40		2,403,139	
				PU12, L≦4m (driving length)	sheet			645.24						
				PU12, L≦2m (driving length)	sheet			527.92						
			2). Sheet pile press fitting	PU, L≦15m (driving length)	sheet			165.71	5,233					
				PU, L≦12m (driving length)	sheet			130.98	4,139					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU12, 18	t	722.1	881.00			636,160.04			72,102,379	
			5). installation for tie-rod and waling		t	47.7		3,311.13			157,866.66		1,024,555	
			6). material fee for tie-rod (NHT690)	φ46 L=10.0m 2pcs/rod	nos	2.0			68,175			136,350	136,350	
				φ46 L=11.0m 2pcs/rod	nos	2.0			74,295			148,590	148,590	
				φ46 L=11.5m 2pcs/rod	nos	23.0			77,040			1,771,920	1,771,920	
				φ46 L=12.0m 2pcs/rod	nos	20.0			79,785			1,595,700	1,595,700	
				φ46 L=13.0m 2pcs/rod	nos	2.0			85,905			171,810	171,810	
				φ46 L=13.5m 2pcs/rod	nos	8.0			89,325			714,600	714,600	
				φ46 L=14.0m 2pcs/rod	nos	6.0			92,025			552,150	552,150	
				φ42 L=12.0m 2pcs/rod	nos	8.0			51,255			410,040	410,040	
				φ42 L=9.0m 2pcs/rod	nos	2.0			53,595			107,190	107,190	
				φ42 L=8.5m 2pcs/rod	nos	9.0			69,480			625,320	625,320	
				φ32L=7.5m 2pcs/rod	nos	22.0			27,990			615,780	615,780	
				φ32 L=8.0m 2pcs/rod	nos	1.0			29,385			29,385	29,385	
				φ32 L=9.0m 2pcs/rod	nos	1.0			32,670			32,670	32,670	

Table 4-2.5 Bill of quantities (2/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
				φ25 L=7.5m 2pcs/rod	nos	4.0			21,240			84,960	84,960	
			7). material fee for waling	UPN	t	32.7		12,553.60			410,389.73		2,663,429	
			8). sheet pile welding	on site	nos	293.0		1,944.85			569,841.05		3,698,268	
			9). anticorrosion painting (bitumen)		m2	7,145.3		248.00			1,772,029.44		11,500,471	
	sub total									636,160.04	3,742,433.16	6,996,465	103,387,235	
total										636,160.04	5,394,080.56	6,996,465	114,106,427	
A-5. Bank protection	A-5-1. Bank protection	1. Riprap	1). wet stone pitching	t=35cm	m2	2,008.8		841.71			1,690,827.04		10,973,467	
			2). placing backfill concrete	18N/mm2 by crane	m3	161.4		1,479.36			238,709.52		1,549,225	
			3). curing	plain concrete	m3	161.4		12.92			2,084.77		13,530	
		sum									1,931,621.33		12,536,222	
		2. crown works	1). form for lean concrete		m2	10.2		209.60			2,137.92		13,875	
			2). placing lean concrete	18N/mm2 by crane	m3	1.8		1,479.36			2,640.65		17,138	
			3). curing	plain concrete	m3	1.8		12.92			23.06		150	
			4). formwork	for small structure	m2	107.8		355.10			38,295.03		248,535	
			5). placing plain concrete	18N/mm2 by man power	m3	16.0		1,109.76			17,750.61		115,201	
			6). curing	small structure	m3	17.8		30.22			537.31		3,487	
			7). gravel for under concrete	t=100mm	m2	3.6		99.31			354.53		2,301	
			8). joint filler	expansion joint	m2	1.3		45.20			59.93		389	
		sum									61,799.04		401,076	
		3. base concrete	1). form for lean concrete		m2	10.7		209.60			2,232.24		14,487	
			2). placing lean concrete	18N/mm2 by crane	m3	2.7		1,479.36			3,938.79		25,563	
			3). curing	plain concrete	m3	2.7		12.92			34.39		223	
			4). formwork	for small structure	m2	104.4		355.10			37,089.90		240,713	
			5). placing plain concrete	18N/mm2 by man power	m3	16.4		1,109.76			18,201.72		118,129	
			6). curing	small structure	m3	16.4		30.22			495.65		3,217	
			7). gravel for under concrete	t=100mm	m2	4.5		99.31			445.55		2,892	
			8). joint filler	expansion joint	m2	1.7		45.20			75.27		489	
		sum									62,513.51		405,713	
		4. gabion protection	1). installation for gabion	0.5×1.0×2.0	nos	1,184.0		1,173.37	3,990		1,389,270.08	4,724,160	13,740,523	
				1.0×1.0×2.0	nos	670.0		2,355.33	8,920		1,578,071.10	5,976,400	16,218,081	
		sum									2,967,341.18	10,700,560	29,958,604	
total											5,023,275.06	10,700,560	43,301,615	
A-6. Canal bed protection	A-6-1. bed protection for upstream	1. Bed protection for upstream	1). stone riprap	working radius r=less 9m	m3	956.5		606.24			579,868.56		3,763,347	
			2). grading for riprap		m2	1,952.0		76.86			150,030.72		973,699	
		sum									729,899.28		4,737,046	
	A-6-2. bed protection for downstream	1. Bed protection for downstream	1). stone riprap	working radius r=less 9m	m3	1,701.0		606.24			1,031,214.24		6,692,580	
			2). grading for riprap		m2	1,890.0		76.86			145,265.40		942,772	
			3). gravel for backfill	t=0.1m	m3	208.5		746.76			155,699.46		1,010,489	
			4). geotextile	t=0.5mm, Nylon,polyester	m2	2,085.0		46.42			96,785.70		628,139	
		sum									1,428,964.80		9,273,982	
	A-6-3. Sheet pile for water stop	1. Sheet pile for water stop	1). driving sheet pile	PU 18, L≦15m (driving length)	sheet	1.0		1,466.45			1,466.45		9,517	
				PU 18, L≦12m (driving length)	sheet	3.0		1,231.17			3,693.51		23,971	
				PU 18, L≦9m (driving length)	sheet	4.0		997.84			3,991.36		25,904	
				PU 12, L≦12m (driving length)	sheet	120.0		1,055.19			126,622.80		821,782	
				PU 12, L≦9m (driving length)	sheet	8.0		880.52			7,044.16		45,717	
				PU 12, L≦6m (driving length)	sheet	122.0		761.90			92,951.80		603,257	
				PU 12, L≦4m (driving length)	sheet	120.0		645.24			77,428.80		502,513	
				PU 12, L≦2m (driving length)	sheet	104.0		527.92			54,903.68		356,325	
			2). material fee for sheet pile	PU 12, 18	t	222.5	881.00			196,050.69			22,220,385	
			3). sheet pile welding	on site	nos	31.0		1,944.85			60,290.35		391,284	
			4). anticorrosion painting	sand plasting and painting	m2	193.7		248.00			48,032.64		311,732	
			5). sheet pile cutting		m	24.0		264.24			6,341.76		41,158	
		sum								196,050.69	482,767.31		25,353,545	
total										196,050.69	2,641,631.39		39,364,573	
A-7. Concrete work for regulators	A-7-1. concrete works	regulator body	1). earth foundation finishing		m2	4,553.1		28.06			127,759.42		829,159	
			2). form for lean concrete		m2	51.9		209.60			10,882.43		70,627	
			3). placing lean concrete	18N/mm2 by crane	m3	403.1		1,326.22			534,599.28		3,469,549	
			4). curing	plain concrete	m3	403.1		12.92			5,208.05		33,800	
			5). formwork	reinforced concrete	m2	14,302.0		400.74			5,731,375.46		37,196,627	

Table 4-2.6 Bill of quantities (3/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			6). formwork	circular structure	m2	490.7		525.17			257,706.17		1,672,513	
			7). placing concrete	25N/mm2(src, night time)	m3	14,667.0		1,446.03			21,208,922.01		137,645,904	
			8). placing concrete	25N/mm2(opc)	m3	1,372.5		1,356.29			1,861,467.33		12,080,923	
			9). curing	reinforced concrete	m3	16,039.5		7.83			125,589.05		815,073	
			10). bending,cutting and placing for re-bar	D13～D25mm	t	586.0		17,805.74			10,434,680.00		67,721,073	
			11). scaffolding	not less than 4m	m2	10,755.1		161.52			1,737,170.21		11,274,235	
			12). pipe support falsework	not greater than 4t/m2	m3	4,360.7		144.07			628,244.60		4,077,307	
			13). joint filler	t=20mm	m2	488.7		403.70			197,284.15		1,280,374	
			14). water stop	w=300mm	m	251.0		37.54	2,214		9,423.29	555,758	616,915	
			15). water stop	water-swelling	m	66.1		16.56	1,975		1,093.78	130,448	137,547	
			16). addtive for rust-proofing	for reinforced condrete	m3	16,039.5		124.81			2,001,844.48		12,991,971	
total											44,873,249.71	686,206	291,913,597	
A-8. Pile foundation work	A-8-1. Cast-in-place RC pile	φ1,000	1). mobilization and demobilization		L.S	2.0		297,720.00			595,440.00		3,864,406	
			2). pile drilling	including fabricate and lowering stell cage and pour concrete	m	2,429.6		1,712.00			4,159,475.20		26,994,994	
			3). placing concrete	25N/mm2(src)	m3	1,908.2		1,386.07			2,644,903.45		17,165,423	
			4). bending,cutting and placing for re-bar		t	301.0		17,805.74			5,359,812.63		34,785,184	
			5). pile head demolishing	φ1,000, 0.8m	m3	120.6		469.06			56,586.06		367,244	
			6). load test		L.S	2.0		283,333.00			566,666.00		3,677,662	
total											13,382,883.34		86,854,913	
A-9. Accessory works	A-9-1. Road works	1. Asphalt pavement	1). enbankment		m3	10,225.3		37.90			387,539.62		2,515,132	
		roadway	material fee for temporary road	sand	m3	12,916.2		67.10			866,676.59		5,624,731	
			transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	12,916.2		19.22			248,249.24		1,611,138	
			transportation by damp truck	Distance 20km	m3	12,916.2		135.51			1,750,273.40		11,359,274	
			2). wearing course	t=50mm	m2	4,379.6		143.00			626,287.09		4,064,603	
			3). binder course	t=60mm	m2	4,379.6		143.00			626,287.09		4,064,603	
			4). base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
			5). sub base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
			6). tack coat		m2	4,379.6		16.00			70,074.08		454,781	
			7). prime coat		m2	4,379.6		19.00			83,212.97		540,052	
		sum									5,821,654.62		37,782,538	
		2. Asphalt pavement	1). wearing course	t=50mm	m2	623.7		143.00			89,191.96		578,856	
		pathway	2). base course	t=200mm	m2	623.7		132.78			82,817.54		537,486	
			3). prime coat		m2	623.7		19.00			11,850.68		76,911	
		sum									183,860.18		1,193,253	
		3. curb concrete	1). form for lean concrete		m2	127.3		209.60			26,689.20		173,213	
			2). placing lean concrete	18N/mm2 by crane	m3	20.7		1,479.36			30,585.21		198,498	
			3). curing	plain concrete	m3	20.7		12.92			267.11		1,734	
			3). formwork	for small structure	m2	964.9		355.10			342,646.12		2,223,773	
			4). placing plain concrete	18N/mm2 by man power	m3	109.5		1,109.76			121,480.35		788,407	
			5). curing	small structure	m3	109.5		30.22			3,308.04		21,469	
			6). gravel for under concrete	t=100mm	m2	41.3		99.31			4,106.39		26,650	
		sum									529,082.42		3,433,745	
		4. guard pipe	H=1.1m		m	629.81		1,212.12			763,405.29		4,954,500	
		5. slope protection	1). stone masonry with mortar	t=35cm	m2	1,765.25		841.71			1,485,828.57		9,643,027	
			2). placing backfill concrete	18N/mm2 by crane	m3	214.54		1,479.36			317,374.66		2,059,762	
			3). curing	plain concrete	m3	214.54		12.92			2,771.79		17,989	
		sum									1,805,975.02		11,720,778	
		6. crown concrete	1). form for lean concrete		m2	47.9		209.60			10,031.45		65,104	
			2). placing lean concrete	18N/mm2 by crane	m3	7.9		1,479.36			11,751.29		76,266	
			3). curing	plain concrete	m3	7.9		12.92			102.63		666	
			4). formwork	for small structure	m2	395.9		355.10			140,574.81		912,331	
			5). placing plain concrete	18N/mm2 by man power	m3	59.1		1,109.76			65,531.32		425,298	
			6). curing	small structure	m3	20.7		30.22			624.78		4,055	
			7). gravel for under concrete	t=100mm	m2	15.9		99.31			1,577.73		10,239	
			8). joint filler	expansion joint	m2	5.9		45.20			266.90		1,732	
		sum									230,460.91		1,495,691	
		7. base concrete	1). form for lean concrete		m2	53.7		209.60			11,250.69		73,017	
			2). placing lean concrete	18N/mm2 by crane	m3	13.4		1,479.36			19,851.90		128,839	

Table 4-2.7 Bill of quantities (4/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5 Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			3). curing	plain concrete	m3	13.4		12.92			173.37		1,125	
			4). formwork	for small structure	m2	474.3		355.10			168,431.08		1,093,118	
			5). placing plain concrete	18N/mm2 by man power	m3	72.5		1,109.76			80,417.59		521,910	
			6). curing	small structure	m3	72.5		30.22			2,189.86		14,212	
			7). gravel for under concrete	t=100mm	m2	18.8		99.31			1,865.73		12,109	
			8). joint filler	expansion joint	m2	7.2		45.20			327.53		2,126	
		sum									284,507.75		1,846,455	
		8. concrete stair	1). form for lean concrete		m2	16.9		209.60			3,535.78		22,947	
			2). placing lean concrete	18N/mm2 by crane	m3	8.4		1,479.36			12,417.03		80,587	
			3). curing	plain concrete	m3	8.4		12.92			108.44		704	
			4). formwork	reinforced concrete	m2	118.6		400.74			47,509.37		308,336	
			5). placing concrete	25N/mm2(opc)	m3	31.0		1,356.29			42,068.86		273,027	
			6). curing	reinforced concrete	m3	31.0		7.83			242.86		1,576	
			7). gravel for under concrete	t=100mm	m2	12.5		99.31			1,243.54		8,071	
			8). bending,cutting and placing for re-bar	D12	t	0.4		18,857.16			7,970.69		51,730	
		sum									115,096.57		746,977	
	sub total										9,734,042.76		63,173,938	
	A-9-2. Bridge works	1. concrete work	1). formwork	reinforced concrete	m2	1,696.3		400.74			679,775.92		4,411,746	
			2). placing concrete	25N/mm2(opc)	m3	548.9		1,356.29			744,406.81		4,831,200	
			3). curing	reinforced concrete	m3	548.9		7.83			4,297.53		27,891	
			4). bending,cutting and placing for re-bar	D12	t	105.1		18,857.16			1,981,642.37		12,860,859	
			5). pipe support falsework	not greater than 4t/m2	m3	6,121.3		144.07			881,888.48		5,723,456	
			6). Styrofoam	t=20～150mm	m3	14.0			26,190			366,607	366,607	
		sum									4,292,011.11	366,607	28,221,759	
		2. shoe	1). rubber bearing	330×150×40	nos	20.0			11,760			235,200	235,200	
				330×300×40	nos	40.0			23,590			943,600	943,600	
				150×10,000×20	nos	2.0			108,780			217,560	217,560	
				300×10,000×20	nos	5.0			217,560			1,087,800	1,087,800	
			2). corrosion-proof anchor	Fixed, F25D	nos	12.0			6,930			83,160	83,160	
				Movable, M25D	nos	20.0			8,260			165,200	165,200	
				for F25D	nos	12.0			1,190			14,280	14,280	
				for M25D	nos	20.0			2,940			58,800	58,800	
		sum										2,805,600	2,805,600	
		3. steel expansion joint	1). expansion joint (brof joint)	displacement⊿=20mm	m	24.2		232.34	35,190		5,622.62	851,598	888,089	
			2). expansion joint (brof joint)	displacement⊿=35mm	m	96.8		232.34	55,800		22,490.51	5,401,440	5,547,403	
			3). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
		sum									35,142.21	6,253,038	6,481,111	
		4. balustrade for bridge	1). balustrade	h=1.100	m	165.2		1,212.12			200,242.22		1,299,572	
			2). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
		sum									207,271.30		1,345,191	
	sub total										4,534,424.62	9,425,245	38,853,661	
	A-9-3. Approach slab	1. concrete work	1). formwork	reinforced concrete	m2	96.0		400.74			38,471.04		249,677	
			2). placing concrete	25N/mm2(opc)	m3	160.0		1,356.29			217,006.40		1,408,372	
			3). curing	reinforced concrete	m3	160.0		7.83			1,252.80		8,131	
			4). bending,cutting and placing for re-bar	D22	t	14.2		17,805.74			253,553.73		1,645,564	
			5). Anchor cap	SGP φ40×80	nos	200.0		67.00			13,400.00		86,966	
			6). Anchor bar	D22×500×200nos	t	0.3		11,442.00			3,478.36		22,575	
			7). joint filler	expansion joint	m2	34.4		45.20			1,554.88		10,091	
		sum									528,717.21		3,431,375	
		2. shoe	1). rubber shoe	t=30mm	m2	24.0			166,050			3,985,200	3,985,200	
	sub total										528,717.21	3,985,200	7,416,575	
	A-9-4. Accessory works around regulator	1. accessory work for gate	1). formwork for post-placing concrete	reinforced concrete	m2	1,248.8		400.74			500,448.11		3,247,908	
			2). post-placing concrete	25N/mm2(src, night time)	m3	340.2		1,446.03			491,953.86		3,192,781	
			3). post-placing concrete	25N/mm2(opc)	m3	7.5		1,356.29			10,185.73		66,105	
			4). curing	for post-placing concrete	m3	347.7		7.83			2,722.64		17,670	
			5). joint bar	D22	t	2.9		11,442.00			33,457.14		217,137	
			6). installation for joint bar	D22	nos	7,900.0		83.45			659,255.00		4,278,565	
		sum									1,698,022.48		11,020,166	
		2. hydraulic pipe pit works	1). form for lean concrete		m2	9.1		209.60			1,909.45		12,392	

Table 4-2.8 Bill of quantities (5/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). placing lean concrete	18N/mm2 by crane	m3	10.5		1,479.36			15,562.86		101,003	
			3). curing	plain concrete	m3	10.5		12.92			135.91		882	
			4). formwork	reinforced concrete	m2	374.7		400.74			150,169.30		974,599	
			5). placing concrete	25N/mm2(opc)	m3	85.8		1,356.29			116,383.24		755,327	
			6). curing	reinforced concrete	m3	85.8		7.83			671.89		4,361	
			7). bending,cutting and placing for re-bar	D22	t	8.5		17,805.74			151,687.09		984,449	
			8). scaffolding	not less than 4m	m2	160.1		161.52			25,865.81		167,869	
			9). pipe support falsework	not greater than 4t/m2	m3	92.0		144.07			13,250.11		85,993	
			10). water stop	w=300mm	m	16.8		37.54	2,214		630.67	37,195	41,288	
			11). joint filler	expansion joint	m2	5.1		45.20			231.87		1,505	
			12). joint filler	construction joint	m2	0.6		403.70			250.29		1,624	
			13). checker plate	t=3.2mm	m2	1.0		349.41			342.41		2,222	
				t=4.5mm	m2	18.8		476.12			8,946.24		58,061	
			14). Anchor bar	D16	t	0.0		11,442.00			57.11		371	
			15). installation for hydraulic pipe	SUS 32A	m	4,004.0		75.50			302,302.00		1,961,940	
		sum									788,396.25	37,195	5,153,887	
		3. steel stairs	1). steel stairs		L.S	2.0		129,944.00			259,888.00		1,686,673	
			2). foundation for support		L.S	2.0		14,774.67			29,549.34		191,775	
		sum									289,437.34		1,878,448	
		4. installation for grating		IB, 44×5×3	m2	227.8		232.34	18,090		52,936.34	4,121,625	4,465,182	
		5. installation for handrail		H=1.1m	m	563.2		1,395.28			785,821.69		5,099,983	
		6. crane facility	1). chain block	manual operation, 5t	L.S	2.0		32,157.16			64,314.32		417,400	
			2). rail	I 300x150x10x18.5	t	1.1		15,692.00			16,711.98		108,461	
		sum									81,026.30		525,861	
		7. installation for steel steps	b=300mm		nos	765.0		370.65			283,547.25		1,840,222	
		8. staff gauge			m	65.2		1,664.10			108,416.02		703,620	
		9. gate lighting	1). high pressure mercury lamp	400W	nos	6.0		5,075.00			30,450.00		197,621	
			2). installation for gate lighting		nos	6.0		18,533.63			111,201.78		721,700	
		sum									141,651.78		919,320	
		10. water level detector	1). water level detector	DC4-20A	nos	13.0		34,927.58			454,058.55		2,946,840	
			2). installation for water level detector		nos	13.0		2,744.00			35,672.00		231,511	
		sum									489,730.55		3,178,351	
	sub total										4,718,986.00	4,158,820	34,785,039	
total											19,516,170.59	17,569,265	144,229,212	
A-10. Electric works	A-10-1. installation for facilities of receiving po	1. Installation for power receiving and distribu	1). installation for power receiving and distribution panel		nos	1.0		3,388.00			3,388.00		21,988	
			2). emergency generator with panel	80kVA, 3phase 4wire	nos	1.0			8,650,000			8,650,000	8,650,000	
			3). installation for backup generator		nos	1.0		33,246.50			33,246.50		215,770	
			4). transformer	three phase100KVA	nos	1.0		211,500.00			211,500.00		1,372,635	
	sub total										248,134.50	8,650,000	10,260,393	
	A-10-2. Installation for electric cable and wire	1. electric cable and wire	1). electric cable											
			CV 3.5sq -2C		m	323.6		43.25			13,995.70		90,832	
			CV 8sq -2C		m	340.3		66.44			22,609.53		146,736	
			CV 14sq -2C		m	40.0		92.29			3,691.60		23,958	
			CV 22sq -2C		m	20.0		124.83			2,496.60		16,203	
			CV 2sq -3C		m	64.5		41.83			2,698.03		17,510	
			CV 5.5sq -3C		m	268.6		71.80			19,285.48		125,163	
			CV 8sq -3C		m	458.6		87.30			40,035.78		259,832	
			CV 14sq -3C		m	820.4		123.72			101,499.88		658,734	
			CV 22sq -3C		m	125.8		168.44			21,189.75		137,521	
			CV 38sq -3C		m	225.2		254.94			57,412.48		372,607	
			CV 8sq -4C		m	20.0		110.31			2,206.20		14,318	
			CV 38sq -4C		m	30.0		327.64			9,829.20		63,792	
			CVV 2sq -4C		m	5.0		52.36			261.80		1,699	
			CVV 2sq -5C		m	969.3		63.91			61,947.96		402,042	
			CVV 2sq -8C		m	919.8		86.62			79,673.07		517,078	
			CVV 2sq -10C		m	74.5		106.68			7,947.66		51,580	
			CVV 2sq -20C		m	785.2		191.53			150,389.35		976,027	
			CVV 2sq -30C		m	4,164.6		253.71			1,056,600.66		6,857,338	
			CVVS 2sq -2C		m	451.5		47.59			21,486.88		139,450	

Table 4-2.9 Bill of quantities (6/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			CVVS 2sq -10C		m	497.6		124.83			62,115.40		403,129	
			CVVS 2sq -15C		m	113.8		174.84			19,896.79		129,130	
			CVVS 2sq -30C		m	910.4		272.75			248,311.60		1,611,542	
			2). electric wire											
			IV 3.5sq		m	819.6		25.93			21,252.22		137,927	
			IV 5.5sq		m	95.1		29.50			2,805.45		18,207	
			IV 8sq		m	1,050.8		36.46			38,312.16		248,646	
			IV 14sq		m	351.0		52.56			18,448.56		119,731	
			IV 22sq		m	30.0		69.60			2,088.00		13,551	
			CPEV 0.9mm -3P		m	1,521.8		48.34			73,563.81		477,429	
			3). conduits											
			FEP 30		m	576.6		72.87			42,016.84		272,689	
			FEP 40		m	990.8		83.30			82,533.64		535,643	
			FEP 50		m	45.8		96.10			4,401.38		28,565	
			FEP 65		m	155.8		114.00			17,761.20		115,270	
			FEP 80		m	762.8		139.03			106,052.08		688,278	
			FEP 100		m	613.2		188.15			115,373.58		748,775	
			FEP 125		m	474.8		232.23			110,262.80		715,606	
			G 28		m	285.2		163.84			46,727.16		303,259	
			G 36		m	458.9		201.06			92,266.43		598,809	
		sum									2,779,446.71		18,038,609	
		2. earth work	excavasion and backfill		m3	32.0		116.67			3,733.44		24,230	
		3. handhole	900×900×900		nos	32.0		18,600.65			595,220.80		3,862,983	
	sub total										3,378,400.95		21,925,822	
total											3,626,535.45	8,650,000	32,186,215	
A-11. Gate manufactures and works	A-11-1. gate manufacture	1. Gate manufacture	1). double stage roller gate	h=1.100										
			gate leaf	6.0×6.55	L.S	2.0			157,655,000			315,310,000	315,310,000	
			gate guide		L.S	2.0			132,187,000			264,374,000	264,374,000	
			hoisting device	hydraulic	L.S	2.0			410,835,000			821,670,000	821,670,000	
			remote operation system		L.S	2.0			110,893,000			221,786,000	221,786,000	
			2). slide gate	small gate										
			for Badraman	2.0×2.65, including hoist	L.S	2.0		461,044.07			922,088.13		5,984,352	
			for Diroutiah	2.0×2.35, including hoist	L.S	3.0		461,044.07			1,383,132.20		8,976,528	
			for Abo Gabal	2.0×2.95, including hoist	L.S	4.0		499,464.41			1,997,857.62		12,966,096	
			for Sahelyia	2.0×3.55, including hoist	L.S	2.0		527,406.47			1,054,812.94		6,845,736	
			3). stop log											
			for large regulator	Type-A×2、Type-B×8	L.S	2.0		2,368,089.98			4,736,179.96		30,737,808	
			for asmall regulator	Type-A×2、Type-B×7	L.S	2.0		1,128,160.86			2,256,321.72		14,643,528	
		sum									12,350,392.57	1,623,140,000	1,703,294,048	
	A-11-2. installation for gate facilities	1. Installation for manufactures	1). installation for gate	for gate, gate guide, hoist	L.S	1.0		5,372,924.63			5,372,924.63		34,870,281	
			2). installation for stop log	for gate guide, crane	L.S	1.0		1,351,345.63			1,351,345.63		8,770,233	
			3). control panel for gate operation											
			remote operation panel		nos	1.0		6,860.00			6,860.00		44,521	
			4). Japanese mechanical engineer for gate		day	1,050.0			22,154			23,261,700	23,261,700	
			5). Japanese electrical engineer for gate		day	1,050.0			24,698			25,932,900	25,932,900	
		sum									6,731,130.26	49,194,600	92,879,635	
total											19,081,522.83	1,672,334,600	1,796,173,683	
A-12. Expense of the machine and facilities	A-12-1. Expense of the machine and facilities	1. Rent fee for heavy equipment	1-1. rent in Egypt											
			1). rough terrain crane	25t	day	1,410.0		3,194.17			4,503,775.00		29,229,500	
			2). truck with crane	4t/2.9t	day	1,350.0		1,927.50			2,602,125.00		16,887,791	
			3). Truck	11t	day	1,350.0		1,591.67			2,148,750.00		13,945,388	
			4). Truck mixer	4.4m3	day	1,260.0		2,150.00			2,709,000.00		17,581,410	
			5). Truck mixer	4.4m3	day	1,230.0		2,150.00			2,644,500.00		17,162,805	
			6). Truck mixer	4.4m3	day	915.0		2,150.00			1,967,250.00		12,767,453	
			7). Truck mixer	4.4m3	day	450.0		2,150.00			967,500.00		6,279,075	
			8). cement silo	50t	day	1,290.0		1,595.83			2,058,625.00		13,360,476	
			9). Wheel Loader	2.1m3	day	400.0		2,030.83			812,333.33		5,272,043	
			1-2. rent in Japan											
			1). Batching plant	30m3/h	LS	1.0	221,309.66			221,309.66			25,083,237	

Table 4-2.10 Bill of quantities (7/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0			21,100			31,797,700	31,797,700	
			3). Vibration hunmer (2)	Hydraulic, 232KW	day	367.0			21,100			7,743,700	7,743,700	
			4). Water jet	14.7Mpa 325L/min	day	1,507.0			9,370			14,120,590	14,120,590	
		sum								221,309.66	20,413,858.33	53,661,990	211,231,167	
		2. Operator wage	rent in Egypt											
			1). rough terrain crane	25t	day	1,058.0		435.00			460,230.00		2,986,893	
			2). truck with crane	4t/2.9t	day	1,013.0		435.00			440,655.00		2,859,851	
			3). Truck	11t	day	1,013.0		435.00			440,655.00		2,859,851	
			4). Truck mixer	4.4m3	day	945.0		435.00			411,075.00		2,667,877	
			5). Truck mixer	4.4m3	day	923.0		435.00			401,505.00		2,605,767	
			6). Truck mixer	4.4m3	day	687.0		435.00			298,845.00		1,939,504	
			7). Truck mixer	4.4m3	day	338.0		435.00			147,030.00		954,225	
		sum									2,599,995.00		16,873,968	
		3. Fuel fee	rent in Egypt											
			1). rough terrain crane	25t	Lit	122,696.2		2.00			245,392.40		1,592,597	
			2). truck with crane	4t/2.9t	Lit	39,091.6		2.00			78,183.20		507,409	
			3). Truck	11t	Lit	61,620.7		2.00			123,241.40		799,837	
			4). Truck mixer	4.4m3	Lit	57,900.1		2.00			115,800.20		751,543	
			5). Truck mixer	4.4m3	Lit	56,552.2		2.00			113,104.40		734,048	
			6). Truck mixer	4.4m3	Lit	42,092.4		2.00			84,184.80		546,359	
			7). Truck mixer	4.4m3	Lit	20,709.2		2.00			41,418.40		268,805	
		sum									801,324.80		5,200,598	
total										221,309.66	23,815,178.13	53,661,990	233,305,733	
B. Temporary Works										3,192,139.21	88,433,278.12	262,773,263	**1,198,502,296**	
B-1. Temporary Coffer Dam	B-1-1. Double Sheet Pile	1. Double sheet pile	1). driving sheet pile	PU28+1, L≦15m (driving length)	sheet			1,730.41						
				PU28+1, L≦12m (driving length)	sheet	1,462.0		1,466.45			2,143,949.90		13,914,235	
				PU28+1, L≦9m (driving length)	sheet			1,173.16						
				PU28+1, L≦6m (driving length)	sheet	640.0		939.18			601,075.20		3,900,978	
				PU28+1, L≦4m (driving length)	sheet	80.0		763.21			61,056.80		396,259	
			2). Sheet pile press fitting	PU, L≦9m (driving length)	sheet			103.68	3,280					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU28+1	t	1,907.6	440.50			840,284.40			95,237,834	
			5). material fee for sheet pile	PU28+1, near rail way	t		881.00							
			6). installation for tie-rod and waling		t	293.9		3,311.13			972,988.79		6,314,697	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos	210.0			151,065			31,723,650	31,723,650	
				φ75 L=10.0m 2pcs/rod	nos	29.0			167,850			4,867,650	4,867,650	
				φ32 L=6.8m 2pcs/rod	nos	40.0			25,470			1,018,800	1,018,800	
				φ32 L=8.0m 2pcs/rod	nos	31.0			29,385			910,935	910,935	
				φ28 L=4.5m 2pcs/rod	nos				16,020					
				φ28 L=5.5m 2pcs/rod	nos				18,495					
				φ28 L=7.6m 2pcs/rod	nos				24,345					
				φ28 L=8.5m 2pcs/rod	nos				26,820					
			8). material fee for waling	H300未満	t	106.6		7,846.00			836,383.60		5,428,130	
			9). sheet pile welding	on site	nos	1,662.0		1,944.85			3,232,340.70		20,977,891	
			10). removing sheet pile	L≦15m (removing length)	nos			658.61						
				L≦12m (removing length)	nos	1,462.0		572.16			836,497.92		5,428,872	
				L≦9m (removing length)	nos			486.33						
				L≦6m (removing length)	nos	640.0		428.48			274,227.20		1,779,735	
				L≦4m (removing length)	nos	80.0		371.90			29,752.00		193,090	
			11). driving bearing pile	H150, L≦4m (driving length)	nos			615.91						
				H250, L≦4m (driving length)	nos			673.91						
			12). removing bearing pile	L≦4m (removing length)	nos			371.90						
			13). material fee for bearing pile		t			7,846.00						
			14). Japanese sheet pile operator A		day	2,190.0			27,030			59,195,700	59,195,700	
			15). Japanese sheet pile operator B		fay	480.0			27,030			12,974,400	12,974,400	
	sub total									840,284.40	8,988,272.11	110,691,135	264,262,855	
	B-1-2. Earth work	1. earth work	1). backfill	inside coffer dam	m3	29,986.8		37.90			1,136,499.72		7,375,883	
			2). backfill material fee	sand	m3	40,458.0		67.10			2,714,731.80		17,618,609	
			3). transportation fee for buying material											

Table 4-2.11 Bill of quantities (8/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			excavation and loading	0.8m3 back hoe loose soil	m3	40,458.0		19.22			777,602.76		5,046,642	
			transportation by damp truck	Distance 20km	m3	40,458.0		135.51			5,482,463.58		35,581,189	
	sub total										10,111,297.86		65,622,323	
total										840,284.40	19,099,569.97	110,691,135	329,885,178	
B-2. Single Sheet Pile	B-2-1. Single Sheet Pile	1. Single Sheet Pile	1). driving sheet pile	PU28+1, L≦15m (driving length)	sheet	200.0		1,730.41			346,082.00		2,246,072	
				PU28+1, L≦12m (driving length)	sheet			1,466.45						
				PU28+1, L≦9m (driving length)	sheet			1,173.16						
				PU28+1, L≦6m (driving length)	sheet	232.0		939.18			217,889.76		1,414,105	
				PU28+1, L≦4m (driving length)	sheet	467.0		763.21			356,419.07		2,313,160	
			2). Sheet pile press fitting	PU, L≦9m (driving length)	sheet	195.0		103.68	3,280		20,217.60	639,600	770,812	
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos	1.0		700.36	19,332		700.36	19,332	23,877	
			4). material fee for sheet pile	PU28+1	t	663.3	440.50			292,188.54			33,116,649	
			5). material fee for sheet pile	PU28+1, near rail way	t	165.7	881.00			145,981.70			16,545,566	
			6). installation for tie-rod and waling		t	47.7		3,311.13			157,940.90		1,025,036	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos				151,065					
				φ75 L=10.0m 2pcs/rod	nos				167,850					
				φ32 L=6.8m 2pcs/rod	nos				25,470					
				φ32 L=8.0m 2pcs/rod	nos				29,385					
				φ28 L=4.5m 2pcs/rod	nos	76.0			16,020			1,217,520	1,217,520	
				φ28 L=5.5m 2pcs/rod	nos	76.0			18,495			1,405,620	1,405,620	
				φ28 L=7.6m 2pcs/rod	nos	51.0			24,345			1,241,595	1,241,595	
				φ28 L=8.5m 2pcs/rod	nos	68.0			26,820			1,823,760	1,823,760	
			8). material fee for waling		t	26.7		7,846.00			209,488.20		1,359,578	
			9). sheet pile welding	on site	nos	200.0		1,944.85			388,970.00		2,524,415	
			10). removing sheet pile	L≦15m (removing length)	nos	200.0		658.61			131,722.00		854,876	
				L≦12m (removing length)	nos			572.16						
				L≦9m (removing length)	nos			486.33						
				L≦6m (removing length)	nos	232.0		428.48			99,407.36		645,154	
				L≦4m (removing length)	nos	467.0		371.90			173,677.30		1,127,166	
			11). driving bearing pile	H150, L≦4m (driving length)	nos	227.0		615.91			139,811.57		907,377	
				H250, L≦4m (driving length)	nos	46.0		673.91			30,999.86		201,189	
			12). removing bearing pile	L≦4m (removing length)	nos	273.0		371.90			101,528.70		658,921	
			13). material fee for bearing pile		t	53.0		7,846.00			415,445.70		2,696,243	
total										438,170.24	2,790,300.38	6,347,427	74,118,691	
B-3. Temporary bridge	B-3-1. Temporary bridge	1. pile driving	1). driving H-beam	H400, L≦12m (driving length)	piece	139.0		2,083.01			289,538.39		1,879,104	
				H400, L≦9m (driving length)	piece			1,641.77						
				H350, L≦12m (driving length)	piece	45.0		1,730.41			77,868.45		505,366	
				H350, L≦9m (driving length)	piece	148.0		1,407.14			208,256.72		1,351,586	
				H300, L≦6m (driving length)	piece	55.0		880.52			48,428.60		314,302	
			2). removing H-beam	L≦12m (removing length)	piece	184.0		572.16			105,277.44		683,251	
				L≦9m (removing length)	piece	148.0		486.33			71,976.84		467,130	
				L≦6m (removing length)	piece	55.0		428.48			23,566.40		152,946	
			3). material fee for H-beam	exclude re-used material	t	634.4			33,300			21,123,855	21,123,855	
		sum									824,912.84	21,123,855	26,477,539	
		2. substructure	1). installation for substructure		t	46.7		5,381.06			251,295.50		1,630,908	
			2). removal for substructure		t	46.7		2,884.85			134,722.49		874,349	
			3). material fee for substructure		t	25.6		7,846.00			200,857.60		1,303,566	
		sum									586,875.59		3,808,823	
		3. deck plate	1). installation for deck plate		m2	3,700.0		201.95			747,215.00		4,849,425	
			2). removal for deck plate		m2	3,700.0		103.28			382,136.00		2,480,063	
			3). material fee for deck plate	exclude re-used material	m2	1,916.5			11,700			22,423,160	22,423,160	
		sum									1,129,351.00	22,423,160	29,752,648	
		4. superstructure	1). installation for superstructure		t	468.1		2,736.49			1,280,950.96		8,313,372	
			2). removal for superstructure		t	468.1		1,511.24			707,411.44		4,591,100	
			3). material fee for superstructure	exclude re-used material	t	264.3			33,300			8,801,190	8,801,190	
		sum									1,988,362.40	8,801,190	21,705,662	
		5. guard pipe	1). installation for bridge railing		m	1,164.0		22.56			26,259.84		170,426	
			2). removal for bridge railing		m	1,164.0		12.88			14,992.32		97,300	
			3). material fee for bridge railing	@1.8m	nos	374.0			2,876			1,075,437	1,075,437	

Table 4-2.12 Bill of quantities (9/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work		Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									41,252.16	1,075,437	1,343,164	
		6. stage end	1). installation/removal for stage end	steel plate	m2	317.0		95.64			30,319.78		196,775	
			2). material fee for stage end	steel plate	nos	59.1		6,357.00			375,712.96		2,438,377	
		sum									406,032.74		2,635,152	
total											4,976,786.73	53,423,642	85,722,988	
B-4. Dewatering	B-4-1. Dewatering	1. water pump	1). dewatering by water pump	φ50mm	day・nos	780.0		1,334.29			1,040,746.20		6,754,443	
			2). installation and removal for water pump		nos	8.0		1,238.60			9,908.80		64,308	
		sum									1,050,655.00		6,818,751	
		2. Wellpoint	1). installation/removal for wellpoint	121pcs×2 (Bahr-Yusef, Ibrahimia)	L.S	2.0		221,667.00			443,334.00		2,877,238	
			2). daily operation and control		day	803.0		11,000.00			8,833,000.00		57,326,170	
			3). fuel		Lit	96,360.0		2.00			192,720.00		1,250,753	
		sum									9,469,054.00		61,454,160	
total											10,519,709.00		68,272,911	
B-5. Temporary road & preparation	B-5-1. temporary road	1. temporary road	1). embankment		m3	21,331.2		37.90			808,452.48		5,246,857	
			2). material fee for temporary road	sand	m3	25,270.0		67.10			1,695,617.00		11,004,554	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	25,270.0		19.22			485,689.40		3,152,124	
			transportation by damp truck	Distance 20km	m3	25,270.0		135.51			3,424,337.70		22,223,952	
			4). transportation fee for reused material											
			excavation and loading	0.8m3 back hoe loose soil	m3	2,016.0		19.22			38,747.52		251,471	
			transportation by damp truck	Distance 0.3km	m3	2,016.0		18.47			37,235.52		241,659	
			5). exsiting structure demolition	plain concrete	m3	3,089.3		224.59			693,825.88		4,502,930	
			6). breaked concrete disposal	Distance 20km	m3	3,089.3		194.01			599,355.09		3,889,815	
total											7,783,260.59		50,513,361	
B-6. diversion works	B-6-1. diversion works	1. diversion works	1). river side slope excavation	0.8m3 back hoe	m3	6,281.0		19.82			124,489.42		807,936	
			2). river bed excavation	0.4m3 long arm back hoe	m3	5,089.6		46.86			238,498.65		1,547,856	
			3). excavated soil disposal	Distance 20km	m3	11,370.6		159.33			1,811,677.69		11,757,788	
			4). stone riprap	for rever bed	m3	2,093.0		766.83			1,604,975.19		10,416,289	
			5). Barge	Bahr Yusef:60×10=600m2	day	100.0		50,400.00			5,040,000.00		32,709,600	
				Ibrahimia:35×10=350m2	day	100.0		29,400.00			2,940,000.00		19,080,600	
total											11,759,640.95		76,320,070	
B-7. Other temporary works	B-7-1. Temporary yard preparation	1. Temporary yard preparation	1). spreading gravel		m2	21,000.0		132.78			2,788,380.00		18,096,586	
			2). removal for gravel		m3	4,200.0		28.32			118,944.00		771,947	
			3). excavated soil disposal	distance 30km	m3	4,200.0		159.33			669,186.00		4,343,017	
			4). temporary fence	H=2.0m	m	1,860.0		1,083.00			2,014,380.00		13,073,326	
	sub total										5,590,890.00		36,284,876	
	B-7-2. Foudation improvement work	1. Foudation improvement work	1). embankment		m3	2,676.1		45.37			121,414.65		787,981	
			2). material fee for embankment	sand	m3	3,380.0		67.10			226,798.00		1,471,919	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	3,380.0		19.22			64,963.60		421,614	
			transportation by damp truck	Distance 20km	m3	3,380.0		135.51			458,023.80		2,972,574	
			4). soil improvement	cement mixing	m3	3,189.0		123.60			394,160.40		2,558,101	
			5). installation for steel plate		m2	882.0		3.11			2,743.02		17,802	
			6). removal for steel plate		m2	882.0		2.46			2,169.72		14,081	
			7). material fee for steel plate	1.5m × 3.0m, t=22mm	nos	196.0		3,178.50			622,986.00		4,043,179	
	sub total										1,893,259.19		12,287,252	
	B-7-3. Batching plant facility	1. Batching plant facility	1). assembling and removal for batching plant		L.S	1.0		109,080.79			109,080.79		707,934	
			2). assembling and removal for cement silo		L.S	1.0		57,566.61			57,566.61		373,607	
			3). installation and removal for concrete aggregate yard		L.S	1.0		81,493.48			81,493.48		528,893	
	sub total										248,140.88		1,610,434	
	B-7-4. utility costs	1. Receiving power facilities	1). receiving power equipment		L.S	1.0		8,550.00			8,550.00		55,490	
			2). installation		L.S	1.0		4,918.48			4,918.48		31,921	
			3). foundation concrete	18N/mm2	m3									
			4). foundation gravel		m2	15.0		99.31			1,485.67		9,642	
			5). lean concrete		m3	1.3		1,257.46			1,690.02		10,968	
			6). formwork		m2	4.2		400.74			1,683.10		10,923	
			7). placing concrete	18N/mm2	m3	3.6		1,109.76			3,995.13		25,928	
			8). curing		m3	3.6		12.92			46.51		302	
			9). other materials	0.2% of facilities cost	%	0.2		8,550.00			1,710.00		11,098	

Table 4-2.13 Bill of quantities (10/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									24,078.91		156,272	
		2. electricity facilities	1). electric cable	600V 22mm2-3C	m	2,100.0		179.00			375,900.00		2,439,591	
			2). distribution board	75A-150A	nos	18.0		6,990.00			125,820.00		816,572	
			3). switching board		nos	1.0		5,500.00			5,500.00		35,695	
			4). installation for cable		day・nos	12.0		341.00			4,092.00		26,557	
			5). excavation		m3	585.0		154.56			90,417.60		586,810	
			6). backfill		m3	585.0		88.49			51,766.65		335,966	
		sum									653,496.25		4,241,191	
		3. water facilities	1). well	30m x 1piece	m	30.0								
			2). pump for well		nos	2.0		15,000.00			30,000.00		194,700	
			3). distribution pipe	φ50mm	m	226.0		316.00			71,416.00		463,490	
				φ25mm	m	46.5		136.00			6,324.00		41,043	
			4). valve	φ50mm	nos	5.0		307.00			1,535.00		9,962	
				φ25mm	nos	5.0		307.00			1,535.00		9,962	
			5). bibb cock		nos	7.0		1,491.00			10,437.00		67,736	
		sum									121,247.00		786,893	
		4. electricity connection fee			L.S	1.0		50,000.00			50,000.00		324,500	
		5. electric fee			Kwh	1,596,072.5		2.00			3,192,145.04		20,717,021	
	sub total										4,040,967.20		26,225,877	
	B-7-5. site expense	1. transportation fee for heavy construction equipment	1). Track crane	80t × 10 nos	t	800.0		550.00			440,000.00		2,855,600	
		Cairo - Dirout	2). Track crane	25t × 2 nos	t	50.0		550.00			27,500.00		178,475	
			2). Crawler crane	50t × 16 nos	t	800.0		550.00			440,000.00		2,855,600	
		sum									907,500.00		5,889,675	
		2. vehicle for site management	1). vehicle A	sedan	nos	180.0		15,750.00			2,835,000.00		18,399,150	
		including driver and fuel	2). vehicle B	pick-up	nos	142.0		18,749.00			2,662,358.00		17,278,703	
		sum									5,497,358.00		35,677,853	
		3. oversea travel cost	1). project manager		time	10.0			248,000			2,480,000	2,480,000	
			2). chief civil engeneer		time	10.0			248,000			2,480,000	2,480,000	
			3). civil engeneer 1		time	10.0			248,000			2,480,000	2,480,000	
			4). civil engeneer 2		time	10.0			248,000			2,480,000	2,480,000	
			5). architecture		time	3.0			248,000			744,000	744,000	
			6). mechanical engineer		time	8.0			248,000			1,984,000	1,984,000	
			7). electrical engineer		time	8.0			248,000			1,984,000	1,984,000	
			8). administrator		time	10.0			248,000			2,480,000	2,480,000	
		sum										17,112,000	17,112,000	
	sub total										6,404,858.00	17,112,000	58,679,528	
total											18,178,115.27	17,112,000	135,087,968	
B-8. Transpotation / Shipment	for civil work	B-8-1. packing	1). construction material for civil work	728.3 F/T	L.S	1.0			5,665,521			5,665,521	5,665,521	
			2). steel material for civil work	58.3 F/T	L.S	1.0			563,587			563,587	563,587	
		sum										6,229,108	6,229,108	
		B-8-2. loading	1). custom fee		L.S	2.0			5,900			11,800	11,800	
			2). loading	construction material for civil work	F/T	728.3			5,500			4,005,897	4,005,897	
				steel material for civil work	F/T	58.3			5,500			320,430	320,430	
			3). documentation		L.S	2.0			20,000			40,000	40,000	
		sum										4,378,127	4,378,127	
		B-8-3. ocean transpotation	1). construction material for civil work		F/T	728.3	180.00			131,102.10			14,859,112	
			2). steel material for civil work		F/T	58.3	180.00			10,486.83			1,188,577	
		sum								141,588.93			16,047,689	
		B-8-4. port charge	1). port charge		F/T	786.6		148.00			116,417.56		755,550	
			2). trust money for entry		F/T	786.6		60.00			47,196.31		306,304	
		sum									163,613.87		1,061,854	
		B-8-5. inland transpotation	1). inland transpotation	for permanent work	F/T	786.6		667.00			524,665.65		3,405,080	
				work)	F/T	944.6		667.00			630,061.93		4,089,102	
		sum									1,154,727.58		7,494,182	
		B-8-6. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	563.00	5,241.39	205,577	563.00	5,241.38	205,577	303,404	
		sum								563.00	5,241.38	205,577	303,404	
	sub total									142,151.93	1,323,582.83	10,812,812	35,514,364	
	for temporary work	B-8-7. packing	(from Japan to site)											
			1). material for temporary work	2,130.8 F/T	L.S	1.0			10,732,429			10,732,429	10,732,429	

Table 4-2.14 Bill of quantities (1112)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
						US$	LE	YEN	US$	LE	YEN		
		2). steel material for temporary work	1,479.0 F/T	L.S	1.0			221,659			221,658	221,658	
		3). construction equipments	206.9 F/T	L.S	1.0			2,080,632			2,080,632	2,080,632	
		(from site to Japan)											
		1). material for temporary work	2,056.8 F/T	L.S	1.0			3,219,729			3,219,728	3,219,728	
		2). steel material for temporary work	1,428.6 F/T	L.S	1.0			66,498			66,497	66,497	
		3). construction equipment	186.9 F/T	L.S	1.0			624,190			624,189	624,189	
	sum										16,945,133	16,945,133	
	B-8-8. loading	(from Japan to site)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,130.8			5,500			11,719,516	11,719,516	
			steel material for temporary work	F/T	1,479.0			5,500			8,134,373	8,134,373	
			construction equipment	F/T	206.9			5,500			1,138,129	1,138,129	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
		(from site to Japan)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,056.8		254.24			522,910.48		3,393,689	
			steel material for temporary work	F/T	1,428.6		254.24			363,203.38		2,357,190	
			construction equipment	F/T	186.9		254.24			47,525.22		308,439	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
	sum									933,639.08	21,147,418	27,206,736	
	B-8-9. ocean transpotation	(from Japan to site)											
		1). material for temporary work		F/T	2,130.8	180.00			383,547.82			43,471,310	
		2). steel material for temporary work		F/T	1,479.0	180.00			266,215.86			30,172,906	
		3). construction equipment		F/T	206.9	180.00			37,247.86			4,221,672	
		(from site to Japan)											
		1). material for temporary work		F/T	2,056.8	180.00			370,220.62			41,960,805	
		2). steel material for temporary work		F/T	1,428.6	180.00			257,148.00			29,145,154	
		3). construction equipment		F/T	186.9	180.00			33,647.86			3,813,648	
		(from site to the third country)											
		1). material for steel sheet pile		F/T	2,736.6	90.00			246,292.26			27,914,765	
	sum								1,594,320.28			180,700,261	
	B-8-10. port charge	(from Japan to site)											
		1). port charge		F/T	3,816.7		148.00			564,876.16		3,666,046	
		2). trust money for entry		F/T	3,816.7		60.00			229,003.84		1,486,235	
		(from site to Japan)											
		1). port charge		F/T	3,672.3		148.00			543,502.44		3,527,331	
		2). trust money for entry		F/T	3,672.3		60.00			220,338.82		1,429,999	
	sum									1,557,721.26		10,109,611	
	B-8-11. inland transpotation	(from Alexandria to site)											
		1). inland transpotation	for temporary work	F/T	3,816.7		667.00			2,545,759.45		16,521,979	
			work)	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
		(from site to Alexandria)											
		2). inland transpotation	for temporary work	F/T	3,672.3		667.00			2,449,433.31		15,896,822	
			imported sheet pile	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
	sum									8,645,791.40		56,111,186	
	B-8-12. insurance	1). insurance (from Japan to Site)	I = CIP × 1.1 × r	L.S	1.0	2,731.00	13,277.55	1,979,481	2,731.00	13,277.55	1,979,481	2,375,184	
		2). insurance (from Site to Japan)	I = CIP × 1.1 × r	L.S	1.0	2,628.00	16,487.07	785,113	2,628.00	16,487.06	785,113	1,189,972	
	sum								5,359.00	29,764.61	2,764,594	3,565,155	
sub total									1,599,679.28	11,166,916.35	40,857,145	294,638,082	
for gate facilities	B-8-13. packing	1). gate facilities	951.0 F/T	L.S	1.0			9,448,061			9,448,061	9,448,061	
	sum										9,448,061	9,448,061	
	B-8-14. loading	1). custom fee		L.S	1.0			5,900			5,900	5,900	
		2). loading fee	Gate facilities	F/T	951.0			5,500			5,230,266	5,230,266	
		3). documennt fee		L.S	1.0			20,000			20,000	20,000	
	sum										5,256,166	5,256,166	
	B-8-15. ocean transpotation	1). gate facilities		F/T	951.0	180.00			171,172.36			19,400,675	
	sum								171,172.36			19,400,675	
	B-8-16. port charge	1). port charge		F/T	951.0		148.00			140,741.72		913,414	
		2). trust money for entry		F/T	951.0		60.00			57,057.45		370,303	

Table 4-2.15 Bill of quantities (12/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									197,799.17		1,283,717	
		B-8-17. inland transpotation	1). inland transpotation		F/T	951.0		667.00			634,288.72		4,116,534	
		sum									634,288.72		4,116,534	
		B-8-18. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	681.00	3,308.17	8,824,875	681.00	3,308.16	8,824,875	8,923,529	
		sum								681.00	3,308.16	8,824,875	8,923,529	
	sub total									171,853.36	835,396.05	23,529,102	48,428,682	
total										1,913,684.57	13,325,895.23	75,199,059	378,581,128	
C. Building Works											3,399,700.00		**22,064,053**	
Building works		C-1. Control house			L.S	1.0		1,977,700.00			1,977,700.00		12,835,273	
		C-2. Local contrl house	Bahr Yusef		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-3. Local contrl house	Ibrahimia		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-4. Stop log room			L.S	1.0		818,200.00			818,200.00		5,310,118	
total											3,399,700.00		22,064,053	
D. Integrated Water Management System											31,628,443.83		**205,268,600**	
Integrated Water Management System	D-1. IWMS manufactures	1. IWMS manufactures	1). Gauging station	Type-A & B	L.S.	1.0		14,102,971.29			14,102,971.29		91,528,284	
			2). Central monitoring room	in Dirout	L.S.	1.0		1,387,148.88			1,387,148.87		9,002,596	
			3). Monitoring room	in Minia	L.S.	1.0		186,425.96			186,425.96		1,209,904	
	sub total										15,676,546.12		101,740,784	
.	D-2. Installation for IWMS	1. Installation for IWMS	1). installation for Gauging station	Type-A & B	L.S.	1.0		15,816,762.91			15,816,762.90		102,650,791	
			2). installation for Monitoring room	in Dirout and Minia	L.S.	1.0		135,134.81			135,134.81		877,025	
	sub total										15,951,897.71		103,527,816	
total											31,628,443.83		205,268,600	
E. Dispute Board										407,000.00			**46,129,380**	
Dispute Board	E-1. Dispute Board	1. regular Site Visit	1). Monthly Retainer Fee	US$3,000/day	month	45.0	3,000.00			135,000.00			15,300,900	
			2). Monthly Retainer Fee during DNP	US$2,000/day	month	12.0	2,000.00			24,000.00			2,720,160	
			3). Daily Fee	2day for Site Visit ×10nos	day	20.0	3,000.00			60,000.00			6,800,400	
				3day for travel ×10nos	day	30.0	3,000.00			90,000.00			10,200,600	
			4). Expenses	Air ticket, etc.	time	10.0	5,000.00			50,000.00			5,667,000	
		sum								359,000.00			40,689,060	
		2. supposed referrals	1). Additional Daily Fee		time	2.0	3,000.00			6,000.00			680,040	
			2). Reviewing Submission and Drafting Decision	(3+4 days)×2	time	14.0	3,000.00			42,000.00			4,760,280	
		sum								48,000.00			5,440,320	
total										407,000.00			46,129,380	
I-2 Indirect Cost					L.S	1.00				1,485,994.40	93,278,928.15	186,287,138	**960,089,987**	

4. Project Cost Estimation

4-1 Criteria and manual of project cost estimation

There are no official standards for construction cost estimation in Egypt. The project cost is estimated by using Japanese Standards articulated in *JICA's Design & Estimation Manual, Estimate Standards* (hereinafter referred to as 'Manual').

(1) Time of cost estimation and expected commencement date

Time of cost estimation is January 2017. The commencement date is expected in February 2018 according to the memorandum signed on July 2015. The amount of price escalation from the time of cost estimation to the project completion date is included in the price contingency.

(2) Exchange rate

A fixed exchange rate system in the Egyptian market was shifted to a flexible exchange rate system on 3rd of November 2016. At the beginning of the trading, the US$-LE exchange rate was provisionally set at US$1 = LE13, a devaluation of approximately 48%. Also, a reduction of the fuel subsidy was made on 4th of November 2016, and the prices of gasoline, diesel oil, and butane gas were raised.

As of April 2017, the exchange rate system completely shifted to the flexible exchange rate. As a result, the value of LE was going down about half.

These changes in the economic policy of the Egyptian government were the conditions for receiving a loan from the IMF. The exchange rate and the prices will be affected by the policy for a while, and the unstable situation with Egyptian market is predicted to continue.

In order to reflect such social context to the detail cost estimation, exchange rate was applied as the average rate for the three months from February to April 2017, and the risk due to the rapid price increase and unstable exchange rate after November 2016 is covered by the consideration of the price contingency.

As a result, the exchange rate is calculated as follows;

1USD = ¥113.34, 1EUR = ¥121.26, 1LE = ¥6.49

(3) Working days coefficient

1.35 of the ratio was applied to the working days coefficient.

(4) Indirect cost

The ratio of indirect cost was applied based on the cost calculations in the Minutes of Discussions (May 2014).

- Indirect cost for Civil and Temporary Works : 35% of each direct cost
- Indirect cost for Gate Manufacture : 3% of the direct cost

(5) Unit price of manpower, materials, and rental fee of heavy equipment etc.

- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. which are from Japan, the unit price was applied as 90% of the average price between two books for monthly unit price published in Japan. When there was any item not described on the two books, competitive estimations from three companies were applied.
- Labor fee for public work in Tokyo is applied to the unit price of Japanese skilled labor.
- Regarding the unit price of manpower, materials, and rental fee of heavy equipment etc. in Egypt, 100% of the average price of the competitive estimations from three companies was applied.

(6) Price escalation

The price escalation rate in the target country is calculated using the economic growth rate of the world economy and the predicted value of inflation rate set by the IMF.

However, because the avobe calculation method of the price escalation rate is not considered the recent rapid price increase, it is not reflected in reality. Therefore, the recent price escalation was reflected by additional calculation applying a monthly inflation rate issued by the Central Bank of Egypt.

- Price escalation rate for LC :
  total ratio is 18.9% (17.2% of recent price escalation + 1.0% per year during construction)
- Price escalation rate for FC :
  total ratio is 4.2% (1.6% per year during construction)

(7) Depreciation ratio for temporary steel material

Steel material for temporary works has a remaind value even after the completion of the construction. The depreciation ratio for temporary steel material was applied 50% according to the Egyptian law.

4-2 Estimation of the project cost

Project cost estimation was carried out based on final design and quauntity which was discussed after submitting the B/D report.

According to the discussion on the B/D cost estimation, the procurement of steel material was changed from Japan to a third country in Europe, and small scale gates and stoplogs were also changed to be procured in Egypt.

The changing points on the design of regulators from the B/D stage are as follows:

(1) Foundation work: from steel sheet pile to cast-in-place RC pile

(2) Bank protection: embankment and gabion protection were newly added at downstream of the left bank of the Bahr Yusef canal and the right bank of the Ibrahimia canals

(3) Dewatering method: from deepwell method to well-point method

The construction and project cost calculated by the above conditions are as follows. It is the approved cost in the 28th TAC meeting on 26th April 2017, and the updated cost of Integrated Water Management System needs to refer to “Volume II Water Management System”.

Table 4-2.1 Construction and project cost estimation

Item	Unit	Quantity	Amount			Total
			US$	LE	YEN	(Exchange to "YEN")
I Construction Cost	**L.S**	**1**	**6,138,654**	**377,480,579**	**2,219,659,487**	**5,365,263,000**
(breakdown)						
A. Civil Works	L.S	1	1,422,252	213,048,447	1,870,904,765	3,414,787,000
B. Temporary works	L.S	1	4,309,402	117,144,168	348,754,722	1,597,447,000
C. Building works	L.S	1		4,589,565		29,786,000
D. Integrated Water Management System	L.S	1		42,698,399		277,112,000
E. Dispute Board	L.S	1	407,000			46,129,000
II Consultant Service	**L.S**	**1**		**17,131,288**	**277,426,230**	**388,607,000**
III Contingency for Construction	**L.S**	**1**	**577,647**	**93,785,050**	**208,869,958**	**883,006,000**
(breakdown)						
Price Contingency	L.S	1	257,823	71,343,829	93,225,698	585,469,000
Physical Contingency	L.S	1	319,824	22,441,220	115,644,259	297,537,000
IV Contingency for Consultant Service	**L.S**	**1**		**4,256,269**	**26,105,808**	**53,729,000**
(break down)						
Price Contingency	L.S	1		3,237,813	11,651,902	32,665,000
Physical Contingency	L.S	1		1,018,455	14,453,907	21,064,000
V Interest During Construction	**L.S**	**1**			**20,100,000**	**20,100,000**
Project Cost (I～V)			**6,716,301**	**492,653,185**	**2,752,161,483**	**6,710,705,000**
VI Other Cost Estimation	**L.S**	**1**		**94,821,619**		**615,391,000**
(breakdown)						
Administration Cost	L.S	1		25,850,173		167,767,000
VAT	L.S	1		68,971,446		447,624,000
Front-end Fee	L.S	1		-		-
Total Project Cost (I～VI)			**6,716,301**	**587,474,805**	**2,752,161,483**	**7,326,096,000**

This project is aimed at STEP (Special Terms for Economic Partnership) of Japanese ODA Loans. The following items are mainly expected to be applied in this project;

- Steel double-sheet pile method
- overflow double-leaf gate to regulators

Ratio of the goods and services to be procured from Japan ("the Ratio") is shown in Table 4-2.2.

Table 4-2.2 Ratio for STEP loan

Item	Grade	Detail	Unit	Quantity	Amount
A-11. Gate manufactures and works					
1. Gate manufacture	gate leaf	6.0×6.55	L.S	2.0	324,769,300
	gate guide		L.S	2.0	272,305,220
	hoisting device	hydraulic	L.S	2.0	846,320,100
	remote operation system		L.S	2.0	228,439,580
1. Installation for manufactures	Japanese mechanical engineer		day	1,050.0	31,403,295
	Japanese electrical engineer fo		day	1,050.0	35,009,415
sub-total					1,738,246,910
A-12. Expense of the machine and facilities					
1. Rent fee for heavy equipment	2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0	42,926,895
sub-total					42,926,895
B-1. Temporary Coffer Dam					
1. Double sheet pile	14). Japanese sheet pile opera		day	2,190.0	79,914,195
sub-total					79,914,195
B-8. Transportation / Shipment					
	B-8-13. packing	951.0 F/T	L.S	1.0	12,754,883
	B-8-14. loading		L.S	1.0	7,095,825
	B-8-15. ocean transpotation		F/T	951.0	26,190,947
sub-total					46,041,655
Total					1,907,129,655

Ratio of the goods and services to be procured from Japan

1) Construction Cost 5,365,263 10^3 YEN

2) Cost of the goods and services to be procured from Japan 1,907,130 10^3 YEN

2)／1)＝ 35.5% ＞30%

Table 4-2.3 Summary of the project cost estimation

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

Exchange Rate	1USD= 113.34 (YEN)
	1EUR= 121.26 (YEN)
	1LE= 6.49 (YEN)

Item				Unit	Quantity	Amount			Total (Exchange to YEN)	Remarks
						US$	LE	YEN		
I Construction Cost	I-1 Direct Cost	A. Civil Works	A-1. Excavation	L.S	1.0		4,438,016.50		28,802,000	
			A-2. Embankment	L.S	1.0		18,815,688.70		122,113,000	
			A-3. Demolition work	L.S	1.0		131,996.64		856,000	
			A-4. Sheet pile bank protection	L.S	1.0	636,160.04	5,394,080.56	6,996,465	114,106,000	
			A-5. Bank protection	L.S	1.0		5,023,275.06	10,700,560	43,301,000	
			A-6. Canal bed protection	L.S	1.0	196,050.69	2,641,631.39		39,364,000	
			A-7. Concrete work for regulators	L.S	1.0		44,873,249.71	686,206	291,913,000	
			A-8. Pile foundation work	L.S	1.0		13,382,883.34		86,854,000	
			A-9. Accessory works	L.S	1.0		19,516,170.59	17,569,265	144,229,000	
			A-10. Electric works	L.S	1.0		3,626,535.45	8,650,000	32,186,000	
			A-11. Gate manufactures and works	L.S	1.0		19,081,522.83	1,672,334,600	1,796,173,000	
			A-12. Expense of the machine and facilities	L.S	1.0	221,309.66	23,815,178.13	53,661,990	233,305,000	
		sub total (A. Civil works)				1,053,520.39	160,740,228.90	1,770,599,086	2,933,209,000	
		B. Temporary Works	B-1. Temporary Coffer Dam	L.S	1.0	840,284.40	19,099,569.97	110,691,135	329,885,000	
			B-2. Single Sheet Pile	L.S	1.0	438,170.24	2,790,300.38	6,347,427	74,118,000	
			B-3. Temporary bridge	L.S	1.0		4,976,786.73	53,423,642	85,722,000	
			B-4. Dewatering	L.S	1.0		10,519,709.00		68,272,000	
			B-5. Temporary road & preparation	L.S	1.0		7,783,260.59		50,513,000	
			B-6. diversion works	L.S	1.0		11,759,640.95		76,320,000	
			B-7. Other temporary works	L.S	1.0		18,178,115.27	17,112,000	135,087,000	
			B-8. Transpotation / Shipment	L.S	1.0	1,913,684.57	13,325,895.23	75,199,059	378,581,000	
		sub total (B. Temporary works)				3,192,139.21	88,433,278.12	262,773,263	1,198,502,000	
		C. Building Works	C-1. Control house	L.S	1.0		1,977,700.00		12,835,000	
			C-2. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-3. Local contrl house	L.S	1.0		301,900.00		1,959,000	
			C-4. Stop log room	L.S	1.0		818,200.00		5,310,000	
		sub total (C. Building works)					3,399,700.00		22,064,000	
		D. Integrated Water Management System	D-1. IWMS manufactures	L.S	1.0		15,676,546.12		101,740,000	
			D-2. Installation for IWMS	L.S	1.0		15,951,897.71		103,527,000	
		sub total (D. Integrated Water Management System)					31,628,443.83		205,268,000	
		E. Dispute Board	E-1. Dispute Board	L.S	1.0	407,000.00			46,129,000	
		sub total (E. Dispute Board)				407,000.00			46,129,000	
						4,652,659.60	284,201,650.85	2,033,372,349	4,405,173,000	
	I-2 Indirect Cost					1,485,994.40	93,278,928.15	186,287,138	960,089,000	
						6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,000**	
						13.0%	45.7%	41.3%		

			Unit	Quantity	US$	LE	YEN	Total (Exchange to YEN)	Remarks
II Consultant Service	Remuneration		L.S	1.0		10,092,110.00	230,823,000	296,320,000	
	Direct Expense		L.S	1.0		7,039,178.00	46,603,230	92,287,000	
						17,131,288.00	277,426,230	**388,607,000**	
III Contingency for Construction	Price Contingency	LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		71,343,829.43		**463,021,000**	
		FC: 1.6%/year, total ratio is 4.2%	L.S	1.0	257,823.47		93,225,698	**122,448,000**	
	Physical Contingency		%	5.0	319,823.87	22,441,220.42	115,644,259	**297,537,000**	
IV Contingency for Consultant Service	Price Contingency	LC: 1.0%/year, total ratio is 18.9%	L.S	1.0		3,237,813.43		**21,013,000**	
		FC: 1.6%/year, total ratio is 4.2%	L.S	1.0			11,651,902	**11,652,000**	
	Physical Contingency		%	5.0		1,018,455.07	14,453,907	**21,064,000**	
V Interest During Construction	0.01 %/year		L.S	1.0			20,100,000	**20,100,000**	

	US$	LE	YEN	Total (Exchange to YEN)	Remarks
Total Construction Cost (I～V)	6,716,301.34	492,653,185.36	2,752,161,483	**6,710,705,000**	
	11.3%	47.6%	41.1%		

Table 4-2.4 Bill of quantities (1/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
I Construction Cost										6,138,654.00	377,480,579.00	2,219,659,487	**5,365,263,489**	
I-1 Direct Cost										4,652,659.60	284,201,650.85	2,033,372,349	**4,405,173,502**	
A. Civil Works										1,053,520.39	160,740,228.90	1,770,599,086	**2,933,209,173**	
A-1. Excavation	A-1-1. Excavation	1. excavation	1). excavation and loading	0.8m3 back hoe	m3	23,390.0		19.82			463,589.80		3,008,698	
			2). excavation for concrete basement	0.8m3 back hoe	m3	1,320.0		28.32			37,382.40		242,612	
		sum									500,972.20		3,251,310	
		2. excavated soil disposal	1). excavated soil disposal	Distance 20km	m3	24,710.0		159.33			3,937,044.30		25,551,418	
total											4,438,016.50		28,802,727	
A-2. Embankment	A-2-1. Embankment	1. Embankment	1). backfill 1	15t bulldozer	m3	76,490.0		37.90			2,898,971.00		18,814,322	
			2). backfill 2	vibration roller,tamping machine	m3	7,470.0		45.37			338,913.90		2,199,551	
			3). material fee for backfill	sand	m3	60,873.0		67.10			4,084,578.30		26,508,913	
		sum									7,322,463.20		47,522,786	
		2. transportation fee for buying material	1). excavation and loading	0.8m3 back hoe loose soil	m3	60,873.0		19.22			1,169,979.06		7,593,164	
			2). transportation by damp truck	Distance 20km	m3	60,873.0		135.51			8,248,900.23		53,535,362	
		sum									9,418,879.29		61,128,527	
		3. transportation fee for reused material	1). excavation and loading	0.8m3 back hoe loose soil	m3	45,183.0		19.22			868,417.26		5,636,028	
			2). transportation by damp truck	Distance 0.3km	m3	45,183.0		18.47			834,530.01		5,416,100	
		sum									1,702,947.27		11,052,128	
		4. Earth finishing	1). earth finishing foundation		m3	4,640.0		7.36			34,150.40		221,636	
			2). rough finishing	0.8m3 back hoe	m2	1,610.0		34.70			55,867.00		362,577	
		sum									90,017.40		584,213	
		5. protection fence for waterpollution	1). protection fence		m	253.0		1,112.18			281,381.54		1,826,166	
total											18,815,688.70		122,113,820	
A-3. Demolition work	A-3-1. Demolition work	1. Demolition work	1). concrete demolition	reinforced concrete	m3	195.4		469.06			91,663.70		594,897	
			2). concrete demolition	plain concrete	m3	5.8		224.59			1,298.13		8,425	
			3). breaked concrete disposal	Distance 20km	m3	201.2		194.01			39,034.81		253,336	
total											131,996.64		856,658	
A-4. Sheet pile bank protection	A-4-1. Capping concrete	1. crown works	1). formwork	reinforced concrete	m2	1,663.9		400.74			666,791.28		4,327,475	
			2). placing reinforced concrete	25N/mm2 by crane	m3	517.9		1,356.29			702,409.02		4,558,635	
			3). curing	reinforced concrete	m3	517.9		7.83			4,055.07		26,317	
			4). bending,cutting and placing for re-bar	D12	t	13.6		18,857.16			256,777.94		1,666,489	
			5). joint filler	@10m	m2	53.5		403.70			21,614.09		140,275	
	sub total										1,651,647.40		10,719,192	
	A-4-2. Sheet pile	1. Sheet pile protection	1). driving sheet pile	PU18, L≦15m (driving length)	sheet	126.0		1,466.45			184,772.70		1,199,175	
				PU18, L≦12m (driving length)	sheet	146.0		1,231.17			179,750.82		1,166,583	
				PU18, L≦9m (driving length)	sheet	43.0		997.84			42,907.12		278,467	
				PU12, L≦12m (driving length)	sheet			1,055.19						
				PU12, L≦9m (driving length)	sheet	62.0		880.52			54,592.24		354,304	
				PU12, L≦6m (driving length)	sheet	486.0		761.90			370,283.40		2,403,139	
				PU12, L≦4m (driving length)	sheet			645.24						
				PU12, L≦2m (driving length)	sheet			527.92						
			2). Sheet pile press fitting	PU, L≦15m (driving length)	sheet			165.71	5,233					
				PU, L≦12m (driving length)	sheet			130.98	4,139					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU12, 18	t	722.1	881.00			636,160.04			72,102,379	
			5). installation for tie-rod and waling		t	47.7		3,311.13			157,866.66		1,024,555	
			6). material fee for tie-rod (NHT690)	φ46 L=10.0m 2pcs/rod	nos	2.0			68,175			136,350	136,350	
				φ46 L=11.0m 2pcs/rod	nos	2.0			74,295			148,590	148,590	
				φ46 L=11.5m 2pcs/rod	nos	23.0			77,040			1,771,920	1,771,920	
				φ46 L=12.0m 2pcs/rod	nos	20.0			79,785			1,595,700	1,595,700	
				φ46 L=13.0m 2pcs/rod	nos	2.0			85,905			171,810	171,810	
				φ46 L=13.5m 2pcs/rod	nos	8.0			89,325			714,600	714,600	
				φ46 L=14.0m 2pcs/rod	nos	6.0			92,025			552,150	552,150	
				φ42 L=12.0m 2pcs/rod	nos	8.0			51,255			410,040	410,040	
				φ42 L=9.0m 2pcs/rod	nos	2.0			53,595			107,190	107,190	
				φ42 L=8.5m 2pcs/rod	nos	9.0			69,480			625,320	625,320	
				φ32L=7.5m 2pcs/rod	nos	22.0			27,990			615,780	615,780	
				φ32 L=8.0m 2pcs/rod	nos	1.0			29,385			29,385	29,385	
				φ32 L=9.0m 2pcs/rod	nos	1.0			32,670			32,670	32,670	

Table 4-2.5 Bill of quantities (2/12)

1	as of Estimation	January . 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
				φ25 L=7.5m 2pcs/rod	nos	4.0			21,240			84,960	84,960	
			7). material fee for waling	UPN	t	32.7		12,553.60			410,389.73		2,663,429	
			8). sheet pile welding	on site	nos	293.0		1,944.85			569,841.05		3,698,268	
			9). anticorrosion painting (bitumen)		m2	7,145.3		248.00			1,772,029.44		11,500,471	
	sub total									636,160.04	3,742,433.16	6,996,465	103,387,235	
total										636,160.04	5,394,080.56	6,996,465	114,106,427	
A-5. Bank protection	A-5-1. Bank protection	1. Riprap	1). wet stone pitching	t=35cm	m2	2,008.8		841.71			1,690,827.04		10,973,467	
			2). placing backfill concrete	18N/mm2 by crane	m3	161.4		1,479.36			238,709.52		1,549,225	
			3). curing	plain concrete	m3	161.4		12.92			2,084.77		13,530	
		sum									1,931,621.33		12,536,222	
		2. crown works	1). form for lean concrete		m2	10.2		209.60			2,137.92		13,875	
			2). placing lean concrete	18N/mm2 by crane	m3	1.8		1,479.36			2,640.65		17,138	
			3). curing	plain concrete	m3	1.8		12.92			23.06		150	
			4). formwork	for small structure	m2	107.8		355.10			38,295.03		248,535	
			5). placing plain concrete	18N/mm2 by man power	m3	16.0		1,109.76			17,750.61		115,201	
			6). curing	small structure	m3	17.8		30.22			537.31		3,487	
			7). gravel for under concrete	t=100mm	m2	3.6		99.31			354.53		2,301	
			8). joint filler	expansion joint	m2	1.3		45.20			59.93		389	
		sum									61,799.04		401,076	
		3. base concrete	1). form for lean concrete		m2	10.7		209.60			2,232.24		14,487	
			2). placing lean concrete	18N/mm2 by crane	m3	2.7		1,479.36			3,938.79		25,563	
			3). curing	plain concrete	m3	2.7		12.92			34.39		223	
			4). formwork	for small structure	m2	104.4		355.10			37,089.90		240,713	
			5). placing plain concrete	18N/mm2 by man power	m3	16.4		1,109.76			18,201.72		118,129	
			6). curing	small structure	m3	16.4		30.22			495.65		3,217	
			7). gravel for under concrete	t=100mm	m2	4.5		99.31			445.55		2,892	
			8). joint filler	expansion joint	m2	1.7		45.20			75.27		489	
		sum									62,513.51		405,713	
		4. gabion protection	1). installation for gabion	0.5×1.0×2.0	nos	1,184.0		1,173.37	3,990		1,389,270.08	4,724,160	13,740,523	
				1.0×1.0×2.0	nos	670.0		2,355.33	8,920		1,578,071.10	5,976,400	16,218,081	
		sum									2,967,341.18	10,700,560	29,958,604	
total											5,023,275.06	10,700,560	43,301,615	
A-6. Canal bed protection	A-6-1. bed protection for upstream	1. Bed protection for upstream	1). stone riprap	working radius r=less 9m	m3	956.5		606.24			579,868.56		3,763,347	
			2). grading for riprap		m2	1,952.0		76.86			150,030.72		973,699	
		sum									729,899.28		4,737,046	
	A-6-2. bed protection for downstream	1. Bed protection for downstream	1). stone riprap	working radius r=less 9m	m3	1,701.0		606.24			1,031,214.24		6,692,580	
			2). grading for riprap		m2	1,890.0		76.86			145,265.40		942,772	
			3). gravel for backfill	t=0.1m	m3	208.5		746.76			155,699.46		1,010,489	
			4). geotextile	t=0.5mm, Nylon,polyester	m2	2,085.0		46.42			96,785.70		628,139	
		sum									1,428,964.80		9,273,982	
	A-6-3. Sheet pile for water stop	1. Sheet pile for water stop	1). driving sheet pile	PU 18, L≦15m (driving length)	sheet	1.0		1,466.45			1,466.45		9,517	
				PU 18, L≦12m (driving length)	sheet	3.0		1,231.17			3,693.51		23,971	
				PU 18, L≦9m (driving length)	sheet	4.0		997.84			3,991.36		25,904	
				PU 12, L≦12m (driving length)	sheet	120.0		1,055.19			126,622.80		821,782	
				PU 12, L≦9m (driving length)	sheet	8.0		880.52			7,044.16		45,717	
				PU 12, L≦6m (driving length)	sheet	122.0		761.90			92,951.80		603,257	
				PU 12, L≦4m (driving length)	sheet	120.0		645.24			77,428.80		502,513	
				PU 12, L≦2m (driving length)	sheet	104.0		527.92			54,903.68		356,325	
			2). material fee for sheet pile	PU 12, 18	t	222.5	881.00			196,050.69			22,220,385	
			3). sheet pile welding	on site	nos	31.0		1,944.85			60,290.35		391,284	
			4). anticorrosion painting	sand plasting and painting	m2	193.7		248.00			48,032.64		311,732	
			5). sheet pile cutting		m	24.0		264.24			6,341.76		41,158	
		sum								196,050.69	482,767.31		25,353,545	
total										196,050.69	2,641,631.39		39,364,573	
A-7. Concrete work for regulators	A-7-1. concrete works	regulator body	1). earth foundation finishing		m2	4,553.1		28.06			127,759.42		829,159	
			2). form for lean concrete		m2	51.9		209.60			10,882.43		70,627	
			3). placing lean concrete	18N/mm2 by crane	m3	403.1		1,326.22			534,599.28		3,469,549	
			4). curing	plain concrete	m3	403.1		12.92			5,208.05		33,800	
			5). formwork	reinforced concrete	m2	14,302.0		400.74			5,731,375.46		37,196,627	

Table 4-2.6 Bill of quantities (3/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			6). formwork	circular structure	m2	490.7		525.17			257,706.17		1,672,513	
			7). placing concrete	25N/mm2(src, night time)	m3	14,667.0		1,446.03			21,208,922.01		137,645,904	
			8). placing concrete	25N/mm2(opc)	m3	1,372.5		1,356.29			1,861,467.33		12,080,923	
			9). curing	reinforced concrete	m3	16,039.5		7.83			125,589.05		815,073	
			10). bending,cutting and placing for re-bar	D13～D25mm	t	586.0		17,805.74			10,434,680.00		67,721,073	
			11). scaffolding	not less than 4m	m2	10,755.1		161.52			1,737,170.21		11,274,235	
			12). pipe support falsework	not greater than 4t/m2	m3	4,360.7		144.07			628,244.60		4,077,307	
			13). joint filler	t=20mm	m2	488.7		403.70			197,284.15		1,280,374	
			14). water stop	w=300mm	m	251.0		37.54	2,214		9,423.29	555,758	616,915	
			15). water stop	water-swelling	m	66.1		16.56	1,975		1,093.78	130,448	137,547	
			16). addtive for rust-proofing	for reinforced condrete	m3	16,039.5		124.81			2,001,844.48		12,991,971	
total											44,873,249.71	686,206	291,913,597	
A-8. Pile foundation work	A-8-1. Cast-in-place RC pile	φ1,000	1). mobilization and demobilization		L.S	2.0		297,720.00			595,440.00		3,864,406	
			2). pile drilling	including fabricate and lowering stell cage and pour concrete	m	2,429.6		1,712.00			4,159,475.20		26,994,994	
			3). placing concrete	25N/mm2(src)	m3	1,908.2		1,386.07			2,644,903.45		17,165,423	
			4). bending,cutting and placing for re-bar		t	301.0		17,805.74			5,359,812.63		34,785,184	
			5). pile head demolishing	φ1,000, 0.8m	m3	120.6		469.06			56,586.06		367,244	
			6). load test		L.S	2.0		283,333.00			566,666.00		3,677,662	
total											13,382,883.34		86,854,913	
A-9. Accessory works	A-9-1. Road works	1. Asphalt pavement roadway	1). enbankment		m3	10,225.3		37.90			387,539.62		2,515,132	
			material fee for temporary road	sand	m3	12,916.2		67.10			866,676.59		5,624,731	
			transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	12,916.2		19.22			248,249.24		1,611,138	
			transportation by damp truck	Distance 20km	m3	12,916.2		135.51			1,750,273.40		11,359,274	
			2). wearing course	t=50mm	m2	4,379.6		143.00			626,287.09		4,064,603	
			3). binder course	t=60mm	m2	4,379.6		143.00			626,287.09		4,064,603	
			4). base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
			5). sub base course	t=200mm	m2	4,379.6		132.78			581,527.27		3,774,112	
			6). tack coat		m2	4,379.6		16.00			70,074.08		454,781	
			7). prime coat		m2	4,379.6		19.00			83,212.97		540,052	
		sum									5,821,654.62		37,782,538	
		2. Asphalt pavement pathway	1). wearing course	t=50mm	m2	623.7		143.00			89,191.96		578,856	
			2). base course	t=200mm	m2	623.7		132.78			82,817.54		537,486	
			3). prime coat		m2	623.7		19.00			11,850.68		76,911	
		sum									183,860.18		1,193,253	
		3. curb concrete	1). form for lean concrete		m2	127.3		209.60			26,689.20		173,213	
			2). placing lean concrete	18N/mm2 by crane	m3	20.7		1,479.36			30,585.21		198,498	
			3). curing	plain concrete	m3	20.7		12.92			267.11		1,734	
			3). formwork	for small structure	m2	964.9		355.10			342,646.12		2,223,773	
			4). placing plain concrete	18N/mm2 by man power	m3	109.5		1,109.76			121,480.35		788,407	
			5). curing	small structure	m3	109.5		30.22			3,308.04		21,469	
			6). gravel for under concrete	t=100mm	m2	41.3		99.31			4,106.39		26,650	
		sum									529,082.42		3,433,745	
		4. guard pipe	H=1.1m		m	629.81		1,212.12			763,405.29		4,954,500	
		5. slope protection	1). stone masonry with mortar	t=35cm	m2	1,765.25		841.71			1,485,828.57		9,643,027	
			2). placing backfill concrete	18N/mm2 by crane	m3	214.54		1,479.36			317,374.66		2,059,762	
			3). curing	plain concrete	m3	214.54		12.92			2,771.79		17,989	
		sum									1,805,975.02		11,720,778	
		6. crown concrete	1). form for lean concrete		m2	47.9		209.60			10,031.45		65,104	
			2). placing lean concrete	18N/mm2 by crane	m3	7.9		1,479.36			11,751.29		76,266	
			3). curing	plain concrete	m3	7.9		12.92			102.63		666	
			4). formwork	for small structure	m2	395.9		355.10			140,574.81		912,331	
			5). placing plain concrete	18N/mm2 by man power	m3	59.1		1,109.76			65,531.32		425,298	
			6). curing	small structure	m3	20.7		30.22			624.78		4,055	
			7). gravel for under concrete	t=100mm	m2	15.9		99.31			1,577.73		10,239	
			8). joint filler	expansion joint	m2	5.9		45.20			266.90		1,732	
		sum									230,460.91		1,495,691	
		7. base concrete	1). form for lean concrete		m2	53.7		209.60			11,250.69		73,017	
			2). placing lean concrete	18N/mm2 by crane	m3	13.4		1,479.36			19,851.90		128,839	

Table 4-2.7 Bill of quantities (4/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
						US$	LE	YEN	US$	LE	YEN		
		3). curing	plain concrete	m3	13.4		12.92			173.37		1,125	
		4). formwork	for small structure	m2	474.3		355.10			168,431.08		1,093,118	
		5). placing plain concrete	18N/mm2 by man power	m3	72.5		1,109.76			80,417.59		521,910	
		6). curing	small structure	m3	72.5		30.22			2,189.86		14,212	
		7). gravel for under concrete	t=100mm	m2	18.8		99.31			1,865.73		12,109	
		8). joint filler	expansion joint	m2	7.2		45.20			327.53		2,126	
	sum									284,507.75		1,846,455	
	8. concrete stair	1). form for lean concrete		m2	16.9		209.60			3,535.78		22,947	
		2). placing lean concrete	18N/mm2 by crane	m3	8.4		1,479.36			12,417.03		80,587	
		3). curing	plain concrete	m3	8.4		12.92			108.44		704	
		4). formwork	reinforced concrete	m2	118.6		400.74			47,509.37		308,336	
		5). placing concrete	25N/mm2(opc)	m3	31.0		1,356.29			42,068.86		273,027	
		6). curing	reinforced concrete	m3	31.0		7.83			242.86		1,576	
		7). gravel for under concrete	t=100mm	m2	12.5		99.31			1,243.54		8,071	
		8). bending,cutting and placing for re-bar	D12	t	0.4		18,857.16			7,970.69		51,730	
	sum									115,096.57		746,977	
sub total										9,734,042.76		63,173,938	
A-9-2. Bridge works	1. concrete work	1). formwork	reinforced concrete	m2	1,696.3		400.74			679,775.92		4,411,746	
		2). placing concrete	25N/mm2(opc)	m3	548.9		1,356.29			744,406.81		4,831,200	
		3). curing	reinforced concrete	m3	548.9		7.83			4,297.53		27,891	
		4). bending,cutting and placing for re-bar	D12	t	105.1		18,857.16			1,981,642.37		12,860,859	
		5). pipe support falsework	not greater than 4t/m2	m3	6,121.3		144.07			881,888.48		5,723,456	
		6). Styrofoam	t=20～150mm	m3	14.0			26,190			366,607	366,607	
	sum									4,292,011.11	366,607	28,221,759	
	2. shoe	1). rubber bearing	330×150×40	nos	20.0			11,760			235,200	235,200	
			330×300×40	nos	40.0			23,590			943,600	943,600	
			150×10,000×20	nos	2.0			108,780			217,560	217,560	
			300×10,000×20	nos	5.0			217,560			1,087,800	1,087,800	
		2). corrosion-proof anchor	Fixed, F25D	nos	12.0			6,930			83,160	83,160	
			Movable, M25D	nos	20.0			8,260			165,200	165,200	
			for F25D	nos	12.0			1,190			14,280	14,280	
			for M25D	nos	20.0			2,940			58,800	58,800	
	sum										2,805,600	2,805,600	
	3. steel expansion joint	1). expansion joint (brof joint)	displacement⊿=20mm	m	24.2		232.34	35,190		5,622.62	851,598	888,089	
		2). expansion joint (brof joint)	displacement⊿=35mm	m	96.8		232.34	55,800		22,490.51	5,401,440	5,547,403	
		3). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
	sum									35,142.21	6,253,038	6,481,111	
	4. balustrade for bridge	1). balustrade	h=1.100	m	165.2		1,212.12			200,242.22		1,299,572	
		2). Anchor bar	D12	t	0.6		11,442.00			7,029.08		45,619	
	sum									207,271.30		1,345,191	
sub total										4,534,424.62	9,425,245	38,853,661	
A-9-3. Approach slab	1. concrete work	1). formwork	reinforced concrete	m2	96.0		400.74			38,471.04		249,677	
		2). placing concrete	25N/mm2(opc)	m3	160.0		1,356.29			217,006.40		1,408,372	
		3). curing	reinforced concrete	m3	160.0		7.83			1,252.80		8,131	
		4). bending,cutting and placing for re-bar	D22	t	14.2		17,805.74			253,553.73		1,645,564	
		5). Anchor cap	SGP φ40×80	nos	200.0		67.00			13,400.00		86,966	
		6). Anchor bar	D22×500×200nos	t	0.3		11,442.00			3,478.36		22,575	
		7). joint filler	expansion joint	m2	34.4		45.20			1,554.88		10,091	
	sum									528,717.21		3,431,375	
	2. shoe	1). rubber shoe	t=30mm	m2	24.0			166,050			3,985,200	3,985,200	
sub total										528,717.21	3,985,200	7,416,575	
A-9-4. Accessory works around regulator	1. accessory work for gate	1). formwork for post-placing concrete	reinforced concrete	m2	1,248.8		400.74			500,448.11		3,247,908	
		2). post-placing concrete	25N/mm2(src, night time)	m3	340.2		1,446.03			491,953.86		3,192,781	
		3). post-placing concrete	25N/mm2(opc)	m3	7.5		1,356.29			10,185.73		66,105	
		4). curing	for post-placing concrete	m3	347.7		7.83			2,722.64		17,670	
		5). joint bar	D22	t	2.9		11,442.00			33,457.14		217,137	
		6). installation for joint bar	D22	nos	7,900.0		83.45			659,255.00		4,278,565	
	sum									1,698,022.48		11,020,166	
	2. hydraulic pipe pit works	1). form for lean concrete		m2	9.1		209.60			1,909.45		12,392	

Table 4-2.8 Bill of quantities (5/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5 Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). placing lean concrete	18N/mm2 by crane	m3	10.5		1,479.36			15,562.86		101,003	
			3). curing	plain concrete	m3	10.5		12.92			135.91		882	
			4). formwork	reinforced concrete	m2	374.7		400.74			150,169.30		974,599	
			5). placing concrete	25N/mm2(opc)	m3	85.8		1,356.29			116,383.24		755,327	
			6). curing	reinforced concrete	m3	85.8		7.83			671.89		4,361	
			7). bending,cutting and placing for re-bar	D22	t	8.5		17,805.74			151,687.09		984,449	
			8). scaffolding	not less than 4m	m2	160.1		161.52			25,865.81		167,869	
			9). pipe support falsework	not greater than 4t/m2	m3	92.0		144.07			13,250.11		85,993	
			10). water stop	w=300mm	m	16.8		37.54	2,214		630.67	37,195	41,288	
			11). joint filler	expansion joint	m2	5.1		45.20			231.87		1,505	
			12). joint filler	construction joint	m2	0.6		403.70			250.29		1,624	
			13). checker plate	t=3.2mm	m2	1.0		349.41			342.41		2,222	
				t=4.5mm	m2	18.8		476.12			8,946.24		58,061	
			14). Anchor bar	D16	t	0.0		11,442.00			57.11		371	
			15). installation for hydraulic pipe	SUS 32A	m	4,004.0		75.50			302,302.00		1,961,940	
		sum									788,396.25	37,195	5,153,887	
		3. steel stairs	1). steel stairs		L.S	2.0		129,944.00			259,888.00		1,686,673	
			2). foundation for support		L.S	2.0		14,774.67			29,549.34		191,775	
		sum									289,437.34		1,878,448	
		4. installation for grating		IB, 44×5×3	m2	227.8		232.34	18,090		52,936.34	4,121,625	4,465,182	
		5. installation for handrail		H=1.1m	m	563.2		1,395.28			785,821.69		5,099,983	
		6. crane facility	1). chain block	manual operation, 5t	L.S	2.0		32,157.16			64,314.32		417,400	
			2). rail	I 300x150x10x18.5	t	1.1		15,692.00			16,711.98		108,461	
		sum									81,026.30		525,861	
		7. installation for steel steps	b=300mm		nos	765.0		370.65			283,547.25		1,840,222	
		8. staff gauge			m	65.2		1,664.10			108,416.02		703,620	
		9. gate lighting	1). high pressure mercury lamp	400W	nos	6.0		5,075.00			30,450.00		197,621	
			2). installation for gate lighting		nos	6.0		18,533.63			111,201.78		721,700	
		sum									141,651.78		919,320	
		10. water level detector	1). water level detector	DC4-20A	nos	13.0		34,927.58			454,058.55		2,946,840	
			2). installation for water level detector		nos	13.0		2,744.00			35,672.00		231,511	
		sum									489,730.55		3,178,351	
	sub total										4,718,986.00	4,158,820	34,785,039	
total											19,516,170.59	17,569,265	144,229,212	
A-10. Electric works	A-10-1. installation for facilities of receiving po	1. Installation for power receiving and distribu	1). installation for power receiving and distribution pane		nos	1.0		3,388.00			3,388.00		21,988	
			2). emergency generator with panel	80kVA, 3phase 4wire	nos	1.0			8,650,000			8,650,000	8,650,000	
			3). installation for backup generator		nos	1.0		33,246.50			33,246.50		215,770	
			4). transformer	three phase100KVA	nos	1.0		211,500.00			211,500.00		1,372,635	
	sub total										248,134.50	8,650,000	10,260,393	
	A-10-2. Installation for electric cable and wire	1. electric cable and wire	1). electric cable											
			CV 3.5sq -2C		m	323.6		43.25			13,995.70		90,832	
			CV 8sq -2C		m	340.3		66.44			22,609.53		146,736	
			CV 14sq -2C		m	40.0		92.29			3,691.60		23,958	
			CV 22sq -2C		m	20.0		124.83			2,496.60		16,203	
			CV 2sq -3C		m	64.5		41.83			2,698.03		17,510	
			CV 5.5sq -3C		m	268.6		71.80			19,285.48		125,163	
			CV 8sq -3C		m	458.6		87.30			40,035.78		259,832	
			CV 14sq -3C		m	820.4		123.72			101,499.88		658,734	
			CV 22sq -3C		m	125.8		168.44			21,189.75		137,521	
			CV 38sq -3C		m	225.2		254.94			57,412.48		372,607	
			CV 8sq -4C		m	20.0		110.31			2,206.20		14,318	
			CV 38sq -4C		m	30.0		327.64			9,829.20		63,792	
			CVV 2sq -4C		m	5.0		52.36			261.80		1,699	
			CVV 2sq -5C		m	969.3		63.91			61,947.96		402,042	
			CVV 2sq -8C		m	919.8		86.62			79,673.07		517,078	
			CVV 2sq -10C		m	74.5		106.68			7,947.66		51,580	
			CVV 2sq -20C		m	785.2		191.53			150,389.35		976,027	
			CVV 2sq -30C		m	4,164.6		253.71			1,056,600.66		6,857,338	
			CVVS 2sq -2C		m	451.5		47.59			21,486.88		139,450	

Table 4-2.9 Bill of quantities (6/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			CVVS 2sq -10C		m	497.6		124.83			62,115.40		403,129	
			CVVS 2sq -15C		m	113.8		174.84			19,896.79		129,130	
			CVVS 2sq -30C		m	910.4		272.75			248,311.60		1,611,542	
			2). electric wire											
			IV 3.5sq		m	819.6		25.93			21,252.22		137,927	
			IV 5.5sq		m	95.1		29.50			2,805.45		18,207	
			IV 8sq		m	1,050.8		36.46			38,312.16		248,646	
			IV 14sq		m	351.0		52.56			18,448.56		119,731	
			IV 22sq		m	30.0		69.60			2,088.00		13,551	
			CPEV 0.9mm -3P		m	1,521.8		48.34			73,563.81		477,429	
			3). conduits											
			FEP 30		m	576.6		72.87			42,016.84		272,689	
			FEP 40		m	990.8		83.30			82,533.64		535,643	
			FEP 50		m	45.8		96.10			4,401.38		28,565	
			FEP 65		m	155.8		114.00			17,761.20		115,270	
			FEP 80		m	762.8		139.03			106,052.08		688,278	
			FEP 100		m	613.2		188.15			115,373.58		748,775	
			FEP 125		m	474.8		232.23			110,262.80		715,606	
			G 28		m	285.2		163.84			46,727.16		303,259	
			G 36		m	458.9		201.06			92,266.43		598,809	
		sum									2,779,446.71		18,038,609	
		2. earth work	excavasion and backfill		m3	32.0		116.67			3,733.44		24,230	
		3. handhole	900×900×900		nos	32.0		18,600.65			595,220.80		3,862,983	
	sub total										3,378,400.95		21,925,822	
total											3,626,535.45	8,650,000	32,186,215	
A-11. Gate manufactures and works	A-11-1. gate manufacture	1. Gate manufacture	1). double stage roller gate	h=1.100										
			gate leaf	6.0×6.55	L.S	2.0			157,655,000			315,310,000	315,310,000	
			gate guide		L.S	2.0			132,187,000			264,374,000	264,374,000	
			hoisting device	hydraulic	L.S	2.0			410,835,000			821,670,000	821,670,000	
			remote operation system		L.S	2.0			110,893,000			221,786,000	221,786,000	
			2). slide gate	small gate										
			for Badraman	2.0×2.65, including hoist	L.S	2.0		461,044.07			922,088.13		5,984,352	
			for Diroutiah	2.0×2.35, including hoist	L.S	3.0		461,044.07			1,383,132.20		8,976,528	
			for Abo Gabal	2.0×2.95, including hoist	L.S	4.0		499,464.41			1,997,857.62		12,966,096	
			for Sahelyia	2.0×3.55, including hoist	L.S	2.0		527,406.47			1,054,812.94		6,845,736	
			3). stop log											
			for large regulator	Type-A×2、 Type-B×8	L.S	2.0		2,368,089.98			4,736,179.96		30,737,808	
			for asmall regulator	Type-A×2、 Type-B×7	L.S	2.0		1,128,160.86			2,256,321.72		14,643,528	
		sum									12,350,392.57	1,623,140,000	1,703,294,048	
	A-11-2. installation for gate facilities	1. Installation for manufactures	1). installation for gate	for gate, gate guide, hoist	L.S	1.0		5,372,924.63			5,372,924.63		34,870,281	
			2). installation for stop log	for gate guide, crane	L.S	1.0		1,351,345.63			1,351,345.63		8,770,233	
			3). control panel for gate operation											
			remote operation panel		nos	1.0		6,860.00			6,860.00		44,521	
			4). Japanese mechanical engineer for gate		day	1,050.0			22,154			23,261,700	23,261,700	
			5). Japanese electrical engineer for gate		day	1,050.0			24,698			25,932,900	25,932,900	
		sum									6,731,130.26	49,194,600	92,879,635	
total											19,081,522.83	1,672,334,600	1,796,173,683	
A-12. Expense of the machine and facilities	A-12-1. Expense of the machine and facilities	1. Rent fee for heavy equipment	1-1. rent in Egypt											
			1). rough terrain crane	25t	day	1,410.0		3,194.17			4,503,775.00		29,229,500	
			2). truck with crane	4t/2.9t	day	1,350.0		1,927.50			2,602,125.00		16,887,791	
			3). Truck	11t	day	1,350.0		1,591.67			2,148,750.00		13,945,388	
			4). Truck mixer	4.4m3	day	1,260.0		2,150.00			2,709,000.00		17,581,410	
			5). Truck mixer	4.4m3	day	1,230.0		2,150.00			2,644,500.00		17,162,805	
			6). Truck mixer	4.4m3	day	915.0		2,150.00			1,967,250.00		12,767,453	
			7). Truck mixer	4.4m3	day	450.0		2,150.00			967,500.00		6,279,075	
			8). cement silo	50t	day	1,290.0		1,595.83			2,058,625.00		13,360,476	
			9). Wheel Loader	2.1m3	day	400.0		2,030.83			812,333.33		5,272,043	
			1-2. rent in Japan											
			1). Batching plant	30m3/h	LS	1.0	221,309.66			221,309.66			25,083,237	

Table 4-2.10 Bill of quantities (7/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			2). Vibration hunmer (1)	Hydraulic, 232KW	day	1,507.0			21,100			31,797,700	31,797,700	
			3). Vibration hunmer (2)	Hydraulic, 232KW	day	367.0			21,100			7,743,700	7,743,700	
			4). Water jet	14.7Mpa 325L/min	day	1,507.0			9,370			14,120,590	14,120,590	
		sum								221,309.66	20,413,858.33	53,661,990	211,231,167	
		2. Operator wage	rent in Egypt											
			1). rough terrain crane	25t	day	1,058.0		435.00			460,230.00		2,986,893	
			2). truck with crane	4t/2.9t	day	1,013.0		435.00			440,655.00		2,859,851	
			3). Truck	11t	day	1,013.0		435.00			440,655.00		2,859,851	
			4). Truck mixer	4.4m3	day	945.0		435.00			411,075.00		2,667,877	
			5). Truck mixer	4.4m3	day	923.0		435.00			401,505.00		2,605,767	
			6). Truck mixer	4.4m3	day	687.0		435.00			298,845.00		1,939,504	
			7). Truck mixer	4.4m3	day	338.0		435.00			147,030.00		954,225	
		sum									2,599,995.00		16,873,968	
		3. Fuel fee	rent in Egypt											
			1). rough terrain crane	25t	Lit	122,696.2		2.00			245,392.40		1,592,597	
			2). truck with crane	4t/2.9t	Lit	39,091.6		2.00			78,183.20		507,409	
			3). Truck	11t	Lit	61,620.7		2.00			123,241.40		799,837	
			4). Truck mixer	4.4m3	Lit	57,900.1		2.00			115,800.20		751,543	
			5). Truck mixer	4.4m3	Lit	56,552.2		2.00			113,104.40		734,048	
			6). Truck mixer	4.4m3	Lit	42,092.4		2.00			84,184.80		546,359	
			7). Truck mixer	4.4m3	Lit	20,709.2		2.00			41,418.40		268,805	
		sum									801,324.80		5,200,598	
total										221,309.66	23,815,178.13	53,661,990	233,305,733	
B. Temporary Works										3,192,139.21	88,433,278.12	262,773,263	**1,198,502,296**	
B-1. Temporary Coffer Dam	B-1-1. Double Sheet Pile	1. Double sheet pile	1). driving sheet pile	PU28+1, L≦15m (driving length)	sheet			1,730.41						
				PU28+1, L≦12m (driving length)	sheet	1,462.0		1,466.45			2,143,949.90		13,914,235	
				PU28+1, L≦9m (driving length)	sheet			1,173.16						
				PU28+1, L≦6m (driving length)	sheet	640.0		939.18			601,075.20		3,900,978	
				PU28+1, L≦4m (driving length)	sheet	80.0		763.21			61,056.80		396,259	
			2). Sheet pile press fitting	PU, L≦9m (driving length)	sheet			103.68	3,280					
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos			700.36	19,332					
			4). material fee for sheet pile	PU28+1	t	1,907.6	440.50			840,284.40			95,237,834	
			5). material fee for sheet pile	PU28+1, near rail way	t		881.00							
			6). installation for tie-rod and waling		t	293.9		3,311.13			972,988.79		6,314,697	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos	210.0			151,065			31,723,650	31,723,650	
				φ75 L=10.0m 2pcs/rod	nos	29.0			167,850			4,867,650	4,867,650	
				φ32 L=6.8m 2pcs/rod	nos	40.0			25,470			1,018,800	1,018,800	
				φ32 L=8.0m 2pcs/rod	nos	31.0			29,385			910,935	910,935	
				φ28 L=4.5m 2pcs/rod	nos				16,020					
				φ28 L=5.5m 2pcs/rod	nos				18,495					
				φ28 L=7.6m 2pcs/rod	nos				24,345					
				φ28 L=8.5m 2pcs/rod	nos				26,820					
			8). material fee for waling	H300未満	t	106.6		7,846.00			836,383.60		5,428,130	
			9). sheet pile welding	on site	nos	1,662.0		1,944.85			3,232,340.70		20,977,891	
			10). removing sheet pile	L≦15m (removing length)	nos			658.61						
				L≦12m (removing length)	nos	1,462.0		572.16			836,497.92		5,428,872	
				L≦9m (removing length)	nos			486.33						
				L≦6m (removing length)	nos	640.0		428.48			274,227.20		1,779,735	
				L≦4m (removing length)	nos	80.0		371.90			29,752.00		193,090	
			11). driving bearing pile	H150, L≦4m (driving length)	nos			615.91						
				H250, L≦4m (driving length)	nos			673.91						
			12). removing bearing pile	L≦4m (removing length)	nos			371.90						
			13). material fee for bearing pile		t			7,846.00						
			14). Japanese sheet pile operator A		day	2,190.0			27,030			59,195,700	59,195,700	
			15). Japanese sheet pile operator B		fay	480.0			27,030			12,974,400	12,974,400	
	sub total									840,284.40	8,988,272.11	110,691,135	264,262,855	
	B-1-2. Earth work	1. earth work	1). backfill	inside coffer dam	m3	29,986.8		37.90			1,136,499.72		7,375,883	
			2). backfill material fee	sand	m3	40,458.0		67.10			2,714,731.80		17,618,609	
			3). transportation fee for buying material											

Table 4-2.11 Bill of quantities (8/12)

1	as of Estimation	January. 2017		
2	Country	ARAB REPUBLIC OF EGYPT		
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS		
4	Class	AGRICULTURE		
5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
			excavation and loading	0.8m3 back hoe loose soil	m3	40,458.0		19.22			777,602.76		5,046,642	
			transportation by damp truck	Distance 20km	m3	40,458.0		135.51			5,482,463.58		35,581,189	
	sub total										10,111,297.86		65,622,323	
total										840,284.40	19,099,569.97	110,691,135	329,885,178	
B-2. Single Sheet Pile	B-2-1. Single Sheet Pile	1. Single Sheet Pile	1). driving sheet pile	PU28+1, L≦15m (driving length)	sheet	200.0		1,730.41			346,082.00		2,246,072	
				PU28+1, L≦12m (driving length)	sheet			1,466.45						
				PU28+1, L≦9m (driving length)	sheet			1,173.16						
				PU28+1, L≦6m (driving length)	sheet	232.0		939.18			217,889.76		1,414,105	
				PU28+1, L≦4m (driving length)	sheet	467.0		763.21			356,419.07		2,313,160	
			2). Sheet pile press fitting	PU, L≦9m (driving length)	sheet	195.0		103.68	3,280		20,217.60	639,600	770,812	
			3). Mobilization & demobilization	press fitting machine for sheet pile	nos	1.0		700.36	19,332		700.36	19,332	23,877	
			4). material fee for sheet pile	PU28+1	t	663.3	440.50			292,188.54			33,116,649	
			5). material fee for sheet pile	PU28+1, near rail way	t	165.7	881.00			145,981.70			16,545,566	
			6). installation for tie-rod and waling		t	47.7		3,311.13			157,940.90		1,025,036	
			7). material fee for tie-rod (NHT690)	φ75 L=8.9m 2pcs/rod	nos				151,065					
				φ75 L=10.0m 2pcs/rod	nos				167,850					
				φ32 L=6.8m 2pcs/rod	nos				25,470					
				φ32 L=8.0m 2pcs/rod	nos				29,385					
				φ28 L=4.5m 2pcs/rod	nos	76.0			16,020			1,217,520	1,217,520	
				φ28 L=5.5m 2pcs/rod	nos	76.0			18,495			1,405,620	1,405,620	
				φ28 L=7.6m 2pcs/rod	nos	51.0			24,345			1,241,595	1,241,595	
				φ28 L=8.5m 2pcs/rod	nos	68.0			26,820			1,823,760	1,823,760	
			8). material fee for waling		t	26.7		7,846.00			209,488.20		1,359,578	
			9). sheet pile welding	on site	nos	200.0		1,944.85			388,970.00		2,524,415	
			10). removing sheet pile	L≦15m (removing length)	nos	200.0		658.61			131,722.00		854,876	
				L≦12m (removing length)	nos			572.16						
				L≦9m (removing length)	nos			486.33						
				L≦6m (removing length)	nos	232.0		428.48			99,407.36		645,154	
				L≦4m (removing length)	nos	467.0		371.90			173,677.30		1,127,166	
			11). driving bearing pile	H150, L≦4m (driving length)	nos	227.0		615.91			139,811.57		907,377	
				H250, L≦4m (driving length)	nos	46.0		673.91			30,999.86		201,189	
			12). removing bearing pile	L≦4m (removing length)	nos	273.0		371.90			101,528.70		658,921	
			13). material fee for bearing pile		t	53.0		7,846.00			415,445.70		2,696,243	
total										438,170.24	2,790,300.38	6,347,427	74,118,691	
B-3. Temporary bridge	B-3-1. Temporary bridge	1. pile driving	1). driving H-beam	H400, L≦12m (driving length)	piece	139.0		2,083.01			289,538.39		1,879,104	
				H400, L≦9m (driving length)	piece			1,641.77						
				H350, L≦12m (driving length)	piece	45.0		1,730.41			77,868.45		505,366	
				H350, L≦9m (driving length)	piece	148.0		1,407.14			208,256.72		1,351,586	
				H300, L≦6m (driving length)	piece	55.0		880.52			48,428.60		314,302	
			2). removing H-beam	L≦12m (removing length)	piece	184.0		572.16			105,277.44		683,251	
				L≦9m (removing length)	piece	148.0		486.33			71,976.84		467,130	
				L≦6m (removing length)	piece	55.0		428.48			23,566.40		152,946	
			3). material fee for H-beam	exclude re-used material	t	634.4			33,300			21,123,855	21,123,855	
		sum									824,912.84	21,123,855	26,477,539	
		2. substructure	1). installation for substructure		t	46.7		5,381.06			251,295.50		1,630,908	
			2). removal for substructure		t	46.7		2,884.85			134,722.49		874,349	
			3). material fee for substructure		t	25.6		7,846.00			200,857.60		1,303,566	
		sum									586,875.59		3,808,823	
		3. deck plate	1). installation for deck plate		m2	3,700.0		201.95			747,215.00		4,849,425	
			2). removal for deck plate		m2	3,700.0		103.28			382,136.00		2,480,063	
			3). material fee for deck plate	exclude re-used material	m2	1,916.5			11,700			22,423,160	22,423,160	
		sum									1,129,351.00	22,423,160	29,752,648	
		4. superstructure	1). installation for superstructure		t	468.1		2,736.49			1,280,950.96		8,313,372	
			2). removal for superstructure		t	468.1		1,511.24			707,411.44		4,591,100	
			3). material fee for superstructure	exclude re-used material	t	264.3			33,300			8,801,190	8,801,190	
		sum									1,988,362.40	8,801,190	21,705,662	
		5. guard pipe	1). installation for bridge railing		m	1,164.0		22.56			26,259.84		170,426	
			2). removal for bridge railing		m	1,164.0		12.88			14,992.32		97,300	
			3). material fee for bridge railing	@1.8m	nos	374.0			2,876			1,075,437	1,075,437	

Table 4-2.12 Bill of quantities (9/12)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									41,252.16	1,075,437	1,343,164	
		6. stage end	1). installation/removal for stage end	steel plate	m2	317.0		95.64			30,319.78		196,775	
			2). material fee for stage end	steel plate	nos	59.1		6,357.00			375,712.96		2,438,377	
		sum									406,032.74		2,635,152	
total											4,976,786.73	53,423,642	85,722,988	
B-4. Dewatering	B-4-1. Dewatering	1. water pump	1). dewatering by water pump	φ50mm	day・nos	780.0		1,334.29			1,040,746.20		6,754,443	
			2). installation and removal for water pump		nos	8.0		1,238.60			9,908.80		64,308	
		sum									1,050,655.00		6,818,751	
		2. Wellpoint	1). installation/removal for wellpoint	121pcs×2 (Bahr-Yusef, Ibrahimia)	L.S	2.0		221,667.00			443,334.00		2,877,238	
			2). daily operation and control		day	803.0		11,000.00			8,833,000.00		57,326,170	
			3). fuel		Lit	96,360.0		2.00			192,720.00		1,250,753	
		sum									9,469,054.00		61,454,160	
total											10,519,709.00		68,272,911	
B-5. Temporary road & preparation	B-5-1. temporary road	1. temporary road	1). embankment		m3	21,331.2		37.90			808,452.48		5,246,857	
			2). material fee for temporary road	sand	m3	25,270.0		67.10			1,695,617.00		11,004,554	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	25,270.0		19.22			485,689.40		3,152,124	
			transportation by damp truck	Distance 20km	m3	25,270.0		135.51			3,424,337.70		22,223,952	
			4). transportation fee for reused material											
			excavation and loading	0.8m3 back hoe loose soil	m3	2,016.0		19.22			38,747.52		251,471	
			transportation by damp truck	Distance 0.3km	m3	2,016.0		18.47			37,235.52		241,659	
			5). exsiting structure demolition	plain concrete	m3	3,089.3		224.59			693,825.88		4,502,930	
			6). breaked concrete disposal	Distance 20km	m3	3,089.3		194.01			599,355.09		3,889,815	
total											7,783,260.59		50,513,361	
B-6. diversion works	B-6-1. diversion works	1. diversion works	1). river side slope excavation	0.8m3 back hoe	m3	6,281.0		19.82			124,489.42		807,936	
			2). river bed excavation	0.4m3 long arm back hoe	m3	5,089.6		46.86			238,498.65		1,547,856	
			3). excavated soil disposal	Distance 20km	m3	11,370.6		159.33			1,811,677.69		11,757,788	
			4). stone riprap	for rever bed	m3	2,093.0		766.83			1,604,975.19		10,416,289	
			5). Barge	Bahr Yusef:60×10=600m2	day	100.0		50,400.00			5,040,000.00		32,709,600	
				Ibrahimia:35×10=350m2	day	100.0		29,400.00			2,940,000.00		19,080,600	
total											11,759,640.95		76,320,070	
B-7. Other temporary works	B-7-1. Temporary yard preparation	1. Temporary yard preparation	1). spreading gravel		m2	21,000.0		132.78			2,788,380.00		18,096,586	
			2). removal for gravel		m3	4,200.0		28.32			118,944.00		771,947	
			3). excavated soil disposal	distance 30km	m3	4,200.0		159.33			669,186.00		4,343,017	
			4). temporary fence	H=2.0m	m	1,860.0		1,083.00			2,014,380.00		13,073,326	
	sub total										5,590,890.00		36,284,876	
	B-7-2. Foudation improvement work	1. Foudation improvement work	1). embankment		m3	2,676.1		45.37			121,414.65		787,981	
			2). material fee for embankment	sand	m3	3,380.0		67.10			226,798.00		1,471,919	
			3). transportation fee for buying material											
			excavation and loading	0.8m3 back hoe loose soil	m3	3,380.0		19.22			64,963.60		421,614	
			transportation by damp truck	Distance 20km	m3	3,380.0		135.51			458,023.80		2,972,574	
			4). soil improvement	cement mixing	m3	3,189.0		123.60			394,160.40		2,558,101	
			5). installation for steel plate		m2	882.0		3.11			2,743.02		17,802	
			6). removal for steel plate		m2	882.0		2.46			2,169.72		14,081	
			7). material fee for steel plate	1.5m × 3.0m, t=22mm	nos	196.0		3,178.50			622,986.00		4,043,179	
	sub total										1,893,259.19		12,287,252	
	B-7-3. Batching plant facility	1. Batching plant facility	1). assembling and removal for batching plant		L.S	1.0		109,080.79			109,080.79		707,934	
			2). assembling and removal for cement silo		L.S	1.0		57,566.61			57,566.61		373,607	
			3). installation and removal for concrete aggregate yard		L.S	1.0		81,493.48			81,493.48		528,893	
	sub total										248,140.88		1,610,434	
	B-7-4. utility costs	1. Receiving power facilities	1). receiving power equipment		L.S	1.0		8,550.00			8,550.00		55,490	
			2). installation		L.S	1.0		4,918.48			4,918.48		31,921	
			3). foundation concrete	18N/mm2	m3									
			4). foundation gravel		m2	15.0		99.31			1,485.67		9,642	
			5). lean concrete		m3	1.3		1,257.46			1,690.02		10,968	
			6). formwork		m2	4.2		400.74			1,683.10		10,923	
			7). placing concrete	18N/mm2	m3	3.6		1,109.76			3,995.13		25,928	
			8). curing		m3	3.6		12.92			46.51		302	
			9). other materials	0.2% of facilities cost	%	0.2		8,550.00			1,710.00		11,098	

Table 4-2.13 Bill of quantities (10/12)

1	as of Estimation	January . 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									24,078.91		156,272	
		2. electricity facilities	1). electric cable	600V 22mm2-3C	m	2,100.0		179.00			375,900.00		2,439,591	
			2). distribution board	75A-150A	nos	18.0		6,990.00			125,820.00		816,572	
			3). switching board		nos	1.0		5,500.00			5,500.00		35,695	
			4). installation for cable		day・nos	12.0		341.00			4,092.00		26,557	
			5). excavation		m3	585.0		154.56			90,417.60		586,810	
			6). backfill		m3	585.0		88.49			51,766.65		335,966	
		sum									653,496.25		4,241,191	
		3. water facilities	1). well	30m × 1piece	m	30.0								
			2). pump for well		nos	2.0		15,000.00			30,000.00		194,700	
			3). distribution pipe	φ50mm	m	226.0		316.00			71,416.00		463,490	
				φ25mm	m	46.5		136.00			6,324.00		41,043	
			4). valve	φ50mm	nos	5.0		307.00			1,535.00		9,962	
				φ25mm	nos	5.0		307.00			1,535.00		9,962	
			5). bibb cock		nos	7.0		1,491.00			10,437.00		67,736	
		sum									121,247.00		786,893	
		4. electricity connection fee			L.S	1.0		50,000.00			50,000.00		324,500	
		5. electric fee			Kwh	1,596,072.5		2.00			3,192,145.04		20,717,021	
	sub total										4,040,967.20		26,225,877	
	B-7-5. site expense	1. transportation fee for heavy construction equipment	1). Track crane	80t × 10 nos	t	800.0		550.00			440,000.00		2,855,600	
		Cairo - Dirout	2). Track crane	25t × 2 nos	t	50.0		550.00			27,500.00		178,475	
			2). Crawler crane	50t × 16 nos	t	800.0		550.00			440,000.00		2,855,600	
		sum									907,500.00		5,889,675	
		2. vehicle for site management	1). vehicle A	sedan	nos	180.0		15,750.00			2,835,000.00		18,399,150	
		including driver and fuel	2). vehicle B	pick-up	nos	142.0		18,749.00			2,662,358.00		17,278,703	
		sum									5,497,358.00		35,677,853	
		3. oversea travel cost	1). project manager		time	10.0			248,000			2,480,000	2,480,000	
			2). chief civil engeneer		time	10.0			248,000			2,480,000	2,480,000	
			3). civil engeneer 1		time	10.0			248,000			2,480,000	2,480,000	
			4). civil engeneer 2		time	10.0			248,000			2,480,000	2,480,000	
			5). architecture		time	3.0			248,000			744,000	744,000	
			6). mechanical engineer		time	8.0			248,000			1,984,000	1,984,000	
			7). electrical engineer		time	8.0			248,000			1,984,000	1,984,000	
			8). administrator		time	10.0			248,000			2,480,000	2,480,000	
		sum										17,112,000	17,112,000	
	sub total										6,404,858.00	17,112,000	58,679,528	
total											18,178,115.27	17,112,000	135,087,968	
B-8. Transpotation / Shipment	for civil work	B-8-1. packing	1). construction material for civil work	728.3 F/T	L.S	1.0			5,665,521			5,665,521	5,665,521	
			2). steel material for civil work	58.3 F/T	L.S	1.0			563,587			563,587	563,587	
		sum										6,229,108	6,229,108	
		B-8-2. loading	1). custom fee		L.S	2.0			5,900			11,800	11,800	
			2). loading	construction material for civil work	F/T	728.3			5,500			4,005,897	4,005,897	
				steel material for civil work	F/T	58.3			5,500			320,430	320,430	
			3). documentation		L.S	2.0			20,000			40,000	40,000	
		sum										4,378,127	4,378,127	
		B-8-3. ocean transpotation	1). construction material for civil work		F/T	728.3	180.00			131,102.10			14,859,112	
			2). steel material for civil work		F/T	58.3	180.00			10,486.83			1,188,577	
		sum								141,588.93			16,047,689	
		B-8-4. port charge	1). port charge		F/T	786.6		148.00			116,417.56		755,550	
			2). trust money for entry		F/T	786.6		60.00			47,196.31		306,304	
		sum									163,613.87		1,061,854	
		B-8-5. inland transpotation	1). inland transpotation	for permanent work	F/T	786.6		667.00			524,665.65		3,405,080	
				work)	F/T	944.6		667.00			630,061.93		4,089,102	
		sum									1,154,727.58		7,494,182	
		B-8-6. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	563.00	5,241.39	205,577	563.00	5,241.38	205,577	303,404	
		sum								563.00	5,241.38	205,577	303,404	
	sub total									142,151.93	1,323,582.83	10,812,812	35,514,364	
	for temporary work	B-8-7. packing	(from Japan to site)											
			1). material for temporary work	2,130.8 F/T	L.S	1.0			10,732,429			10,732,429	10,732,429	

Table 4-2.14 Bill of quantities (1112)

1	as of Estimation	January. 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
						US$	LE	YEN	US$	LE	YEN		
		2). steel material for temporary work	1,479.0 F/T	L.S	1.0			221,659			221,658	221,658	
		3). construction equipments	206.9 F/T	L.S	1.0			2,080,632			2,080,632	2,080,632	
		(from site to Japan)											
		1). material for temporary work	2,056.8 F/T	L.S	1.0			3,219,729			3,219,728	3,219,728	
		2). steel material for temporary work	1,428.6 F/T	L.S	1.0			66,498			66,497	66,497	
		3). construction equipment	186.9 F/T	L.S	1.0			624,190			624,189	624,189	
	sum										16,945,133	16,945,133	
	B-8-8. loading	(from Japan to site)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,130.8			5,500			11,719,516	11,719,516	
			steel material for temporary work	F/T	1,479.0			5,500			8,134,373	8,134,373	
			construction equipment	F/T	206.9			5,500			1,138,129	1,138,129	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
		(from site to Japan)											
		1). custom fee		L.S	3.0			5,900			17,700	17,700	
		2). loading	material for temporary work	F/T	2,056.8		254.24			522,910.48		3,393,689	
			steel material for temporary work	F/T	1,428.6		254.24			363,203.38		2,357,190	
			construction equipment	F/T	186.9		254.24			47,525.22		308,439	
		3). documentation		L.S	3.0			20,000			60,000	60,000	
	sum									933,639.08	21,147,418	27,206,736	
	B-8-9. ocean transpotation	(from Japan to site)											
		1). material for temporary work		F/T	2,130.8	180.00			383,547.82			43,471,310	
		2). steel material for temporary work		F/T	1,479.0	180.00			266,215.86			30,172,906	
		3). construction equipment		F/T	206.9	180.00			37,247.86			4,221,672	
		(from site to Japan)											
		1). material for temporary work		F/T	2,056.8	180.00			370,220.62			41,960,805	
		2). steel material for temporary work		F/T	1,428.6	180.00			257,148.00			29,145,154	
		3). construction equipment		F/T	186.9	180.00			33,647.86			3,813,648	
		(from site to the third country)											
		1). material for steel sheet pile		F/T	2,736.6	90.00			246,292.26			27,914,765	
	sum								1,594,320.28			180,700,261	
	B-8-10. port charge	(from Japan to site)											
		1). port charge		F/T	3,816.7		148.00			564,876.16		3,666,046	
		2). trust money for entry		F/T	3,816.7		60.00			229,003.84		1,486,235	
		(from site to Japan)											
		1). port charge		F/T	3,672.3		148.00			543,502.44		3,527,331	
		2). trust money for entry		F/T	3,672.3		60.00			220,338.82		1,429,999	
	sum									1,557,721.26		10,109,611	
	B-8-11. inland transpotation	(from Alexandria to site)											
		1). inland transpotation	for temporary work	F/T	3,816.7		667.00			2,545,759.45		16,521,979	
			work)	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
		(from site to Alexandria)											
		2). inland transpotation	for temporary work	F/T	3,672.3		667.00			2,449,433.31		15,896,822	
			imported sheet pile	F/T	2,736.6		667.00			1,825,299.32		11,846,193	
	sum									8,645,791.40		56,111,186	
	B-8-12. insurance	1). insurance (from Japan to Site)	I = CIP × 1.1 × r	L.S	1.0	2,731.00	13,277.55	1,979,481	2,731.00	13,277.55	1,979,481	2,375,184	
		2). insurance (from Site to Japan)	I = CIP × 1.1 × r	L.S	1.0	2,628.00	16,487.07	785,113	2,628.00	16,487.06	785,113	1,189,972	
	sum								5,359.00	29,764.61	2,764,594	3,565,155	
sub total									1,599,679.28	11,166,916.35	40,857,145	294,638,082	
for gate facilities	B-8-13. packing	1). gate facilities	951.0 F/T	L.S	1.0			9,448,061			9,448,061	9,448,061	
	sum										9,448,061	9,448,061	
	B-8-14. loading	1). custom fee		L.S	1.0			5,900			5,900	5,900	
		2). loading fee	Gate facilities	F/T	951.0			5,500			5,230,266	5,230,266	
		3). documennt fee		L.S	1.0			20,000			20,000	20,000	
	sum										5,256,166	5,256,166	
	B-8-15. ocean transpotation	1). gate facilities		F/T	951.0	180.00			171,172.36			19,400,675	
	sum								171,172.36			19,400,675	
	B-8-16. port charge	1). port charge		F/T	951.0		148.00			140,741.72		913,414	
		2). trust money for entry		F/T	951.0		60.00			57,057.45		370,303	

Table 4-2.15 Bill of quantities (12/12)

1	as of Estimation	January . 2017
2	Country	ARAB REPUBLIC OF EGYPT
3	Project	THE PROJECT FOR CONSTRUCTION OF THE NEW DIROUT GROUP OF REGULATORS
4	Class	AGRICULTURE

5	Exchange Rate	1USD= 113.34 (YEN)	1EUR= 121.26 (YEN)	1LE = 6.49 (YEN)

	Work	Item	Grade	Detail	Unit	Quantity	Unit Price			Amount			Exchange to YEN	Remarks
							US$	LE	YEN	US$	LE	YEN		
		sum									197,799.17		1,283,717	
		B-8-17. inland transpotation	1). inland transpotation		F/T	951.0		667.00			634,288.72		4,116,534	
		sum									634,288.72		4,116,534	
		B-8-18. insurance	1). insurance	I = CIP × 1.1 × r	L.S	1.0	681.00	3,308.17	8,824,875	681.00	3,308.16	8,824,875	8,923,529	
		sum								681.00	3,308.16	8,824,875	8,923,529	
	sub total									171,853.36	835,396.05	23,529,102	48,428,682	
total										1,913,684.57	13,325,895.23	75,199,059	378,581,128	
C. Building Works											3,399,700.00		**22,064,053**	
Building works		C-1. Control house			L.S	1.0		1,977,700.00			1,977,700.00		12,835,273	
		C-2. Local contrl house	Bahr Yusef		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-3. Local contrl house	Ibrahimia		L.S	1.0		301,900.00			301,900.00		1,959,331	
		C-4. Stop log room			L.S	1.0		818,200.00			818,200.00		5,310,118	
total											3,399,700.00		22,064,053	
D. Integrated Water Management System											31,628,443.83		**205,268,600**	
Integrated Water Management System	D-1. IWMS manufactures	1. IWMS manufactures	1). Gauging station	Type-A & B	L.S.	1.0		14,102,971.29			14,102,971.29		91,528,284	
			2). Central monitoring room	in Dirout	L.S.	1.0		1,387,148.88			1,387,148.87		9,002,596	
			3). Monitoring room	in Minia	L.S.	1.0		186,425.96			186,425.96		1,209,904	
	sub total										15,676,546.12		101,740,784	
.	D-2. Installation for IWMS	1. Installation for IWMS	1). installation for Gauging station	Type-A & B	L.S.	1.0		15,816,762.91			15,816,762.90		102,650,791	
			2). installation for Monitoring room	in Dirout and Minia	L.S.	1.0		135,134.81			135,134.81		877,025	
	sub total										15,951,897.71		103,527,816	
total											31,628,443.83		205,268,600	
E. Dispute Board										407,000.00			**46,129,380**	
Dispute Board	E-1. Dispute Board	1. regular Site Visit	1). Monthly Retainer Fee	US$3,000/day	month	45.0	3,000.00			135,000.00			15,300,900	
			2). Monthly Retainer Fee during DNP	US$2,000/day	month	12.0	2,000.00			24,000.00			2,720,160	
			3). Daily Fee	2day for Site Visit×10nos	day	20.0	3,000.00			60,000.00			6,800,400	
				3day for travel ×10nos	day	30.0	3,000.00			90,000.00			10,200,600	
			4). Expenses	Air ticket, etc.	time	10.0	5,000.00			50,000.00			5,667,000	
		sum								359,000.00			40,689,060	
		2. supposed referrals	1). Additional Daily Fee		time	2.0	3,000.00			6,000.00			680,040	
			2). Reviewing Submission and Drafting Decision	(3+4 days)×2	time	14.0	3,000.00			42,000.00			4,760,280	
		sum								48,000.00			5,440,320	
total										407,000.00			46,129,380	
I-2 Indirect Cost					L.S	1.00				1,485,994.40	93,278,928.15	186,287,138	**960,089,987**	

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Volume IV –DRAFT BIDDING DOCUMENTS

1. Contents of Works for the Preparation of Bidding Documents

1-1 Regulation and framework of procurement of public works in the Egyptian government

In Egypt, procurement of public works is made based on the Law No.89 of 1998 and its implementation regulations (Ministerial Decree No. 1367 of 1998), commonly referred to as “Tenders Law”. Based on this law, executing agencies of public works prepare bidding documents, and execute pre-qualification, tendering and evaluation, and contract negotiations and signing.

The relevant agencies involved in procurement of public works and their tasks are as follows.

(1)Ministry of Finance: Policy making, issuing decrees on public procurement policy.

(2) Public Service Authority: Regulating and monitoring public contracts.

(3) Public Contracting Office (under MOF): Handling complaints from contractors/suppliers.

(4) Central Auditing Authority: Conducting independent auditing.

According to the assessment of the procurement process of public works in Egypt, in the “Public Procurement Sector Assessment ‐Review of Laws and Practice in the SEMED Region,” which was published by EBRD in 2013, there is no independent authority to handle claims related to public works, and there is also no single entity to formulate policies and execute government procurement process/procedures, even though transparency and efficiency are somewhat secure.

1-2 Differences between the regulations of the Egyptian government and JICA’s guidelines for procurement under Japanese ODA Loans

From the ‘7th Assignment’ started in November 2016, series of works and discussions for the preparation of draft Bidding Documents for NDGRs project were started. Firstly, on the ‘7th Assignment’, the differences between laws and regulations related to procurement in Egypt and JICA’s Procurement Guideline (*Handbook: Guideline for Procurement under Japanese ODA Loans* April 2012) were discussed. The results are summarized in Table 1-2.1.

Table 1-2.1 Comparison between laws in Egypt and JICA’s procurement guideline

JICA Guideline		Egyptian Laws And Regulations	
Article	**Contents**	**Law No./ Article**	**Contents**
1.08	All documents relating to the procurement shall be made in one of the languages; Japanese, English, French, or Spanish.	Ministerial Decree No.1367(1998) Article 7	The book of conditions, the lists, and the specifications shall be translated in case the invitation of tenders and bids in the adjudications is announced abroad, along with mentioning that the Arabic text shall be

			the one relied upon.
3.02	In case only one applicant is pre-qualified as a result of the evaluation, the Borrower should reject this PQ process.	Ministerial Decree No.1367(1998) Article 27	The adjudication may be cancelled in any of the following cases: (a) If one tender only is submitted in the adjudication, or……
5.10	In case only one bidder submits a bid, it does not mean lack of competition. "Single Bid" is only the result of bidding and different from direct contracting.		
4.03	The limitation of guarantor banks to those in the Borrowers country is not acceptable.	Ministerial Decree No.1367(1998) Article 70	If the bid and performance bond is in the form of a letter of guarantee, it shall be issued by one of the accredited local banks.
4.06	If specific national standards are cited, the bidding documents shall state that Japan Industrial Standards or other internationally accepted standards will also be accepted.	Ministerial Decree No.1367(1998) Article 3	Launching adjudications for submission of tenders hall be done on the basis of precise and detailed technical specifications as set by the Technical Committee having experience in the required items and works. It is conditional to observe Egyptian Standard Specifications and the Specifications of governmental Supplies and other specifications to be issued or approved by the concerned Technical Entities.
5.06	Any procedure, under which bids above or below a predetermined value are automatically disqualified, is not permitted.	Law No.89 (1998) Article 15	It may also be cancelled in any one of the following cases: If the value of the least tender would exceed the estimated value.
		Ministerial Decree No.1367(1998) Article 27	The adjudication may be cancelled in any of the following cases: If the amount of the lowest tender exceeds the estimated value.

In Article 4.7 of the Minutes of Discussions dated 21 May 2014 on the Loan Agreement for NDGRs, it was agreed that that JICA Guidelines shall be applied for the procurements in this project. For the preparation of draft Bidding Documents, the issues identified on this table shall be taken into consideration. While JICA Guideline shall prevail, requests from RGBS to follow the Egyptian laws shall be also reflected in the documents as much as possible.

1-3 Framework of the procurement process of the NDGRs project

As stated above, necessary approvals shall be secured within the Ministry, i.e. Head of Irrigation Department for pre-qualification process, issuance of bidding documents, result of tender evaluations (technical and financial), and contracting. Also, legal review by the State Council is necessary for the contract preparation and/or signing. Necessary approvals and time needed for the process is summarized in Table 1-4.1 in the table next page.

Table 1-4.1 Procurement process and necessary time for NDGRs project in MWRI

Bidding Process	**Japanese Side**	**Egyptian Side**			
		Within MWRI		**Outside MWRI**	
	JICA concurrence Necessary?	**Approval necessary?**	**Expected Days**	**Approval necessary?**	**Expected Days**
Prepare PQ Documents					
Submit PQ Draft for concurrence	[✓ YES]/NO	[✓ YES]/NO If "YES": (Name of Office) **(Head, Irrigation Department)**	Maximum 7 days	YES/[✓ NO] If "YES": (Name of Office) ( )	
Prepare the Bid Documents					
Submit PQ Draft for concurrence	[✓ YES]/NO	[✓ YES]/NO **(Head, Irrigation Department)**		YES/[✓ NO] ( )	
Advertise the procurement on newspapers (Invitation for PQ)	YES/[✓ NO]	[✓ YES]/NO **(Head, Irrigation Department)**		YES/[✓ NO] ( )	
Receive the PQ Documents from applicants					
Evaluate PQ Documents to select bidders					
Submit the PQ result for concurrence	[✓ YES]/NO	YES/[✓ NO] ( )		[✓ YES]/NO **(Public Notification Period)**	7 days
Send Bid Documents to selected bidders					
Receive Bid Documents					
Open and Evaluate the Technical Proposal					
Submit Evaluation result on Technical Proposal for Approval	[✓ YES]/NO	[✓ YES]/NO **(Head, Irrigation Department)**	Maximum 7 days	YES/[✓ NO] ( )	
Open the Price Bids only for Eligible Bidders for Technical Proposal					
Prepare the Bid Evaluation Report (Both Tech & Price)					
Obtain Concurrence on the Evaluation Report	[✓ YES]/NO	[✓ YES]/NO **(Head, Irrigation Department)**	Maximum 7 days	[✓ YES]/NO **(Public Notification Period)**	7 days

Approval for Contract Signing	YES/[✓ NO]	[✓ YES]/NO **(Head, Irrigation Department)**		[✓ YES]/NO **(State Council)**	(Contract can be signed and started. If any comments are made by Council, it shall be reflected later.)
Signing of the Contract					
Obtain Concurrence on the Signed Contract	[✓ YES]/NO	YES/[✓ NO] **( )**		[✓ YES]/NO **(State Council)**	
Issue Notice to Proceed, and commence the Contract	YES/NO	YES/[✓ NO] **( )**		YES/[✓ NO] **( )**	

As for the actual record of procurement process in international bidding under RGBS, case of “New Assiut Barrage and Hydropower Plant (Lot 1: Civil Works)” can be referred as sample of International Competitive Bidding under RGBS. On this bidding, procurement process was made on the timeframe indicated below:

- Newspaper Advertisement for PQ: February 2010
  (PQ process took 5 months)
- Distribution of Tender Documents: October 2010
  (Submission deadline was 90 days from the date of invitation)
- Tender close: January 2011
- Commencement of evaluation: March 2011
- Awarding and negotiation: April 2011
- Completion of negotiation: August 2011
- Approval from KfW : December 2011
- Commencement of construction: May 2012

2. Preparation of Draft Bidding Documents

2-1 Contents of draft bidding documents

As stated in Chapter 1-2, the purpose of the series of meetings with RGBS on ‘7th Assignment’ was to ensure a basic understanding of the procurement system under Japan’s ODA as it is the first time for RGBS. Therefore, only explanations of *Standard Bidding Documents under Japanese ODA Loans* October 2012 were made at the time.

During the ‘7th Assignment’, RGBS made opinions to include (1) number of engineers and construction equipment possessed by applicants as a capacity criteria, and (2) list of contractors debarred by the Egyptian government as a non-eligibility criteria. These requests were taken into consideration on the preparation of draft Bidding Documents during the ‘8th Assignment’ in January 2017.

Also during the ‘7th assignment’, RGBS made request to JICA to change the procurement process so as to combine the pre-qualification and bidding process to be made simultaneously, and bidding documents shall be made as “PQ-embedded bidding documents”. This request was based on their intention to shorten the procurement process on the civil works contract. The team considered this issue as appropriate request, however the final decision shall be made by the direct discussion between RGBS and JICA. Under such circumstance, two patterns of draft Bidding Documents (PQ-embedded Documents, and separated PQ/Bidding Documents) were presented on ‘8th Assignment’ period, however discussions thereafter were made basically on PQ-embedded Documents.

2-2 Contents of discussions and understanding with Egyptian side on draft bidding documents (except technical specifications)

On ‘8th assignment’, substantial discussions on the Bidding Documents to be used for NDGRs project were started. Simultaneously with the discussions, various data and information were conveyed from JICA Egypt Office on their existing samples on bidding documents on STEP under Yen-Loan, particularly on Greater Cairo Metro Line No.4 Project. During the ‘8th Assignment’, RGBS revealed its intention to delay commencement of civil works contract by February 2019, one year delay from the original schedule in February 2018. Though a detail of this idea is not yet thoroughly discussed between RGBS and JICA, RGBS considers that this idea would give more time for procurement process.

For this issue, RGBS requested the Study Team to maintain both patterns (though discussions were made on PQ embedded Documents) for the decision in future. Therefore, PQ embedded Documents are adopted as the final product as part of the Final Report, and separated PQ/Bidding Documents are also submitted but only in electric file.

During the ‘9th Assignment’, series of discussions were made mainly on the comments from JICA on the draft Bidding Documents submitted in February. By reflecting results of the discussion, revised version of the Documents were consolidated, as the final for the Assignment in Egypt, and submitted to both RGBS and JICA on 24 April 2017

The contents of discussions during ‘8th Assignment’ and ‘9th Assignment’ on draft Bidding

Documents, including initial presentation from the team, comments from RGBS, information from JICA Egypt Office, conclusion as of 24 February and conclusion as of 24 April, are summarized in Table 2-2.1.

After the completion of ‘9th Assignment’, comments were provided by RGBS on 10 May 2017 and by JICA on 19 May 2017. By reflecting these comments, draft Bidding Documents are finalized as part of the Final Report of the Study. The summary of said comments and reflection on the final Bidding Documents are summarized in Table 2-2.2.

2-3 Draft bidding documents (technical specifications)

As for the technical specifications, an integral part of draft Bidding Documents, discussions with RGBS were started on ‘8th Assignment’ in February 2017. After the confirmation of structure and contents, actual works on the preparation of technical specifications were started.

The contents of technical specifications are as follows:

1) General Provisions

2) General Technical Specifications

    - Civil Works
    - Mechanical and Electrical Works

3) Particular Technical Specifications

    - Civil Works
    - Mechanical and Electrical Works

For the preparation of technical specifications, attentions were paid on the consideration of fair risk allocation among contract parties, and also consistency with contents of general conditions of contract.

The background of discussions with Egyptian side on the technical specifications are as follows:

1) On 7 February 2017, immediately after the start of the ‘8th Assignment’, table of contents of the technical specifications was presented to RGBS and the items listed were discussed and confirmed.

2) Based on the results of a series of discussions with RGBS, 1st version of the technical specifications were prepared and submitted to RGBS on 24 February 2017, immediately before the end of the ‘8th Assignment’.

3) 1st version of the technical specifications were revised taking into consideration the comments from JICA and the results of the series of discussions with RGBS during the ‘9th Assignment’, and the 2nd version was submitted to RGBS on 24 April 2017, immediately before the end of ‘9th Assignment’.

4) After the completion of the ‘9th Assignment’, comments on the 2nd version of the technical specifications were provided by JICA on 30 April and 3 May 2017, and by RGBS on 10 May 2017. After that, the technical specifications was finalized taking into consideration those comments.

Table 2-2.1 Major issues discussed on draft bidding documents during 8th and 9th field surveys in Egypt

General Issue:

Issue	RGBS Comments	Draft Tender Documents (as of 24 February 2017)	JICA Comments (March – April)	Draft Tender Documents (as of Draft Final Report
PQ/Bidding shall be separated, or combined. .	Since when the bidding is to be made has not yet been decided, possibility of time saving by combining PQ and BD is uncertain. Thus, 2 patterns of documents shall be maintained.	2 patterns (PQ/BD separated, or PQ/BD combined) are made.		Combined type is attached as hard copy and soft copy, but separate type are submitted only in soft copies.

Specific Issues on Draft Bidding Documents:

Page	Items	Contents	Point of Discussion	RGBS Comments	Information from JICA Egypt Office (Feb)	Draft Tender Documents (as of 24 February 2017)	JICA Comments (March – April)	Draft Tender Documents (as of Draft Final Report
IFB-2	-	Price of Bid Documents	Minimum price to cover printing cost.	25,000 L.E. in Assiut Barrage. (approx. US$1,500)	In Metro project, it was $10,000. (5,000 pages of drawings and 1,000 pages of documents)	1,000 U.S.Dollars may be appropriate. (Approx.300 pages of drawings and 500 pages of documents.) However, it shall be blank in Draft Bidding Documents at this point of time.	Shall be $1,000	1,000 U.S.Dollars
IFB-2	-	Amount of Bid Security	About 2% of expected contract amount (as per JICA Guideline). This time, 48.8 Million USD is expected, thus 1 Million USD shall be adequate amount.	Between 0.5% to 2 %.	%It shall be in 2%	2% may be appropriate, however only range (between 0.5% to 2%) shall be indicated to Draft Bidding Documents at this point of time.	2%	Approximately 2% (1.1 Million US$)
IFB-2	-	Submission Deadline	Normally 60 days in JICA's Yen Loan projects, but longer time is necessary for large projects.	90 days in Assiut Barrage Project.	90 days in Metro Project	90 days	-	No change (90 days)
BDS-2	ITB 10.1	Language: English	As per JICA Guideline.	English but some part shall be Arabic.	-	English (some part will be translated to Arabic for internal process in MWRI). Bidder shall not be required to submit bids in Arabic.	English	English, however some part of draft bidding documents are translated and submitted to RGBS (not as part of Report) in soft copy.

Page	Items	Contents	Point of Discussion	RGBS Comments	Information from JICA Egypt Office	Draft Tender Documents (as of 24 February 2017)	JICA Comments (March – April)	Draft Tender Documents (as of Draft Final Report
BDS-3	ITB 18.1	Bid Validity	JICA Guideline recommends 120 days, however, DD team proposes 180 days for safety.	In Assiut Barrage Project, it was 270 days.	In Metro, Bid validity period shall be 120 days including the day of the latest submission date.	270 days (9 months)	120 days	Additional explanations were made to JICA to insist 270 days. Awaiting JICA's approval.
EQC -6	2.3.2	Required Annual Turn-Over	As per JICA Guideline (twice of annual average of expected contract amount.)	Depending on the project cost.	-	Temporarily 24 Million U.S. Dollar is set (twice of annual average of construction cost in Loan Agreement), however it shall be revised upon actual issuance of Bid Documents.	-	$26 Million, based on the modified expected contract amount.
EQC -9	2.4.2(b)	Required Similar Experience	JICA Guideline says about 80% of construction volumes expected by the subject Project. However, DD Team suggests 60%, to have more bidders.	Depending on the project cost.	-	Temporarily 60% of work volumes are set (earth works, concrete works, gate size and depth of sheep pile of coffer dam), however it shall be revised upon actual issuance of Bid Documents.	-	(no change)
EQC-11	2.5.1	Financial Resources	As per JICA Guideline (half of annual average of expected contract amount.)	Depending on the project cost.	-	Temporarily 6 Million U.S. Dollar is set (half of annual average of construction cost in Loan Agreement), however it shall be revised upon actual issuance of Bid Documents.		$6.7 Million based on the modified expected contract amount.
BF-57	Form of Bid Security	Bank Guarantee	This format is OK or not (shall strictly follow this form, or not.)	Bid Security shall be in the form of "Unconditional Letter of Credit".	In Metro Project, Bank Guarantee was used for bid security. Letter of Credit is opened in case of procurement goods.	Unconditional Bank Guarantee.	It is not accepted to limit form of bid security.	Additional explanations were made to JICA, showing same limitation in RFP of SV consultant selection. Awaiting JICA's consideration.
PC-4	20.3	Appointment (if not agreed) to be made by	Examples of other past projects are requested.	-	-	Cairo Regional Centre for International Commercial Arbitration	It shall not be in Egypt, in terms of fairness.	Awaiting result of MWRI-JICA discussion on the same issue for RFP of SV Consultant selection.

Table 2-2.2　Major Comments from JICA and RGBS on the Draft Bidding Documents, and reflection on the Final Version

No.	Items	Comments from RGBS (on 10 May 2007)	Comments from JICA (on 19 May 2007)	Notes/Descriptions on the Final Version of Draft Bidding Documents
1	General Comments	• Bidding Documents could be modified in the next stage under management of RGBS by S/V consultant with the concurrence of JICA) • RGBS requests to support the Japanese Contractor by Egyptian Contractor as a joint venture.	—	• Even after the submission of draft Bidding Documents as final product of DD Study this time, it shall be continuously revised by RGBS until the date of actual invitation (bidding). • This issue shall be also considered after the finalization of draft Bidding Documents as final product of DD Study.
2	In case of failure to agree on the composition of the DB, the appointing entity shall appoint this member of the DB.	Place of arbitration shall be in Cairo.	Considering the Contractor may be foreign, entity in Cairo is not adequate to make appointment in terms of neutrality. FIDIC is recommended.	The appointing entity to appoint this member of the DB shall be FIDIC.
3	Temporary Yard	The Contractor shall lease 3 Feddans (in the expense of the RGBS) for a period of three years.	—	Included this issue in Technical Specifications. However, lease shall be made by RGBS as per instructed by JICA.
4	Legal Review on the Contract by State Council	The Contract shall be subject to the legal review of Egyptian Council of State according to laws of the Arab Republic of Egypt.	(Accepted)	No change from bidding documents attached to the Draft Final Report. (as proposed by RGBS)
5	Bid Validity (JICA Guideline recommends 120 days)	(It shall be 270 days.)	(Accepted)	No change from bidding documents attached to the Draft Final Report. (as proposed by RGBS)
6	Eligibility of MWRI (not having been declared ineligible by NWRI) is included in 2.1.4 of “2.1 Eligibility” of qualification.	(Eligibility of MWRI shall be included in PQ criteria.)	Such additional ineligible condition that is not specified in the Guidelines is not permitted in principle, because of concerns to transparency and arbitrariness.	Followed descriptions in JICA’s Standard Bidding Documents.
7	In 19.2 of Instruction to Bidders, four (4) forms for demand guarantee are indicated as Bid Security.	(Only Unconditioned Guarantee shall be allowed.)	Note 3, Section 4.03 of the Guidelines states as below: "It is not acceptable to prohibit bidders from submitting their securities in internationally accepted forms, such as bank guarantees or letters of credit. Such requirements would discourage suitable bidders from participating".	Followed descriptions in JICA’s Standard Bidding Documents.

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Volume V – ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

1. Environmental and Social Considerations

1-1 Project components that impact environment and society

The NDGRs Project is to construct new regulators at 140m downstream of the existing DGRs, which are located almost at the center of Dirout city. More than 100 years ago, the DGRs were located at the edge of the city, however, the annual urban expansion brought the DGRs to the center of the city.

The DGRs consist of two large regulators, namely, Bahr Yusef regulator and Ibrahimia regulator, and three relatively small scale regulators, namely, Abo Gabal regulator, Badraman regulator and Sahelyia regulator. Due to the recent deterioration of the DGRs, they have not functioned well, however, the DGRS will be preserved as a road, a bridge and a historical monument even after the NDGR construction. New Bahr Yusef regulator and New Ibrahimia regulator will be constructed about 140 m downstream of the current site, while other small scale gate structures will be reconstructed beside the existing ones. Locations of canals concerned and existing/new regulators are illustrated in Figure 1-1.1.

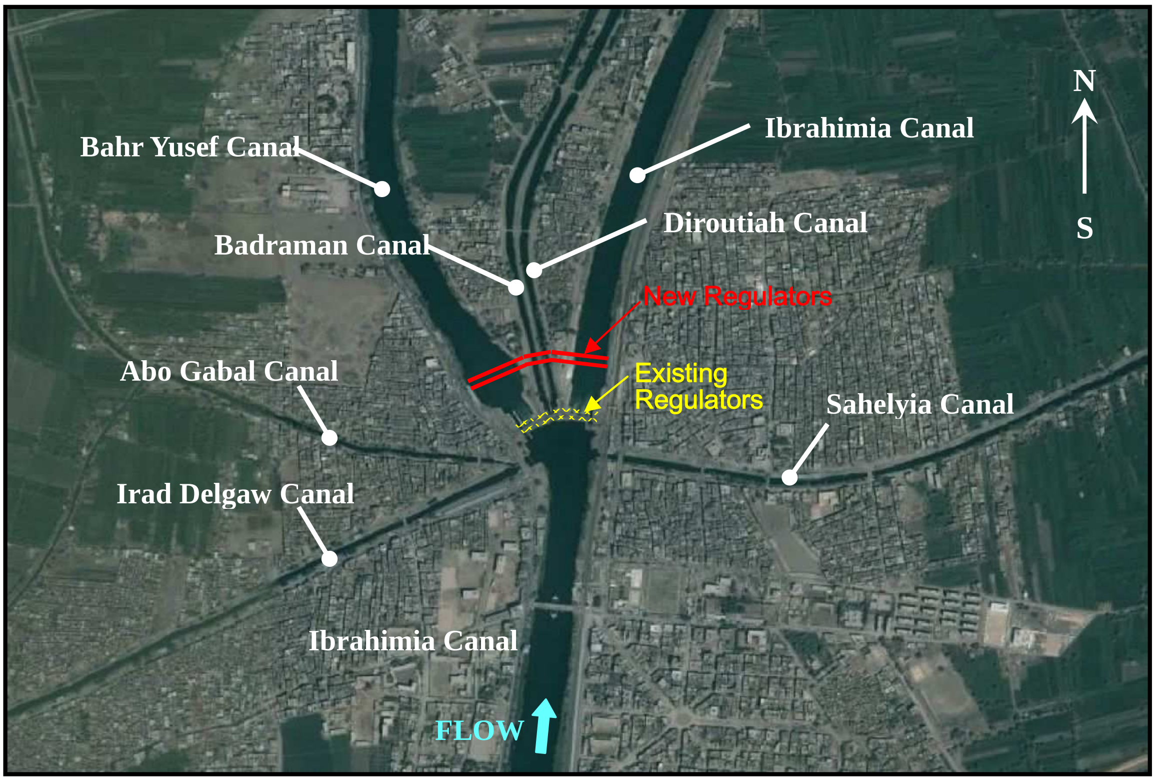
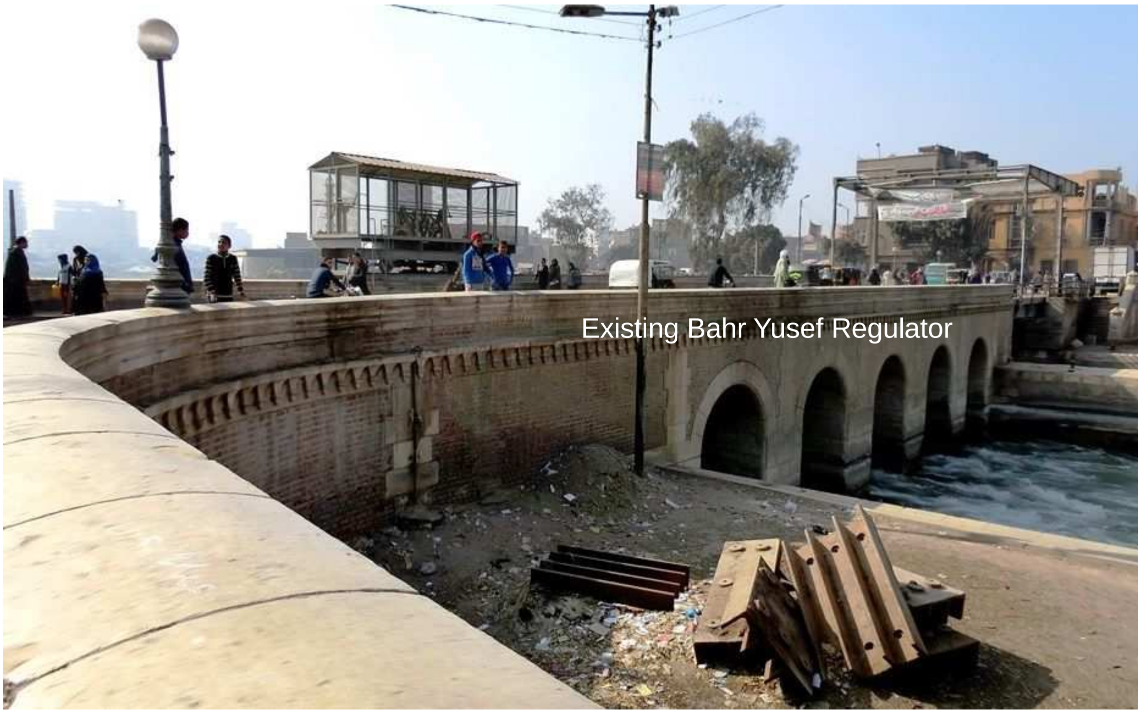


Figure 1-1.1 Location map of the regulators

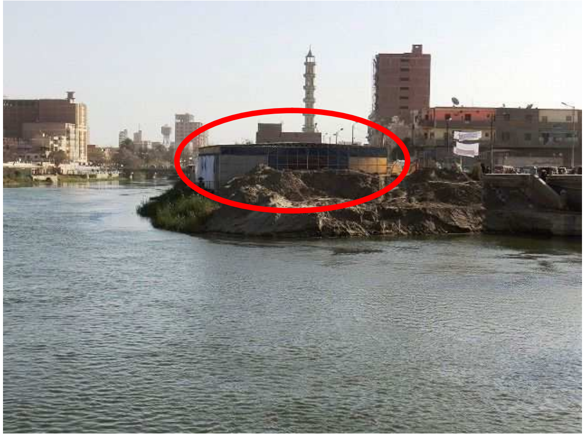
1-2 Basic environmental and social conditions

(1) General conditions around the regulators

The regulators are located on the center of Dirout City, just beside of Dirout Railway Station, it is used as a bridge and a road by many people (See photo below). Also, there are many shops and buildings around the regulators. Farmlands stretch over the beneficial area and no virgin natural area such as marsh and forest is identified.



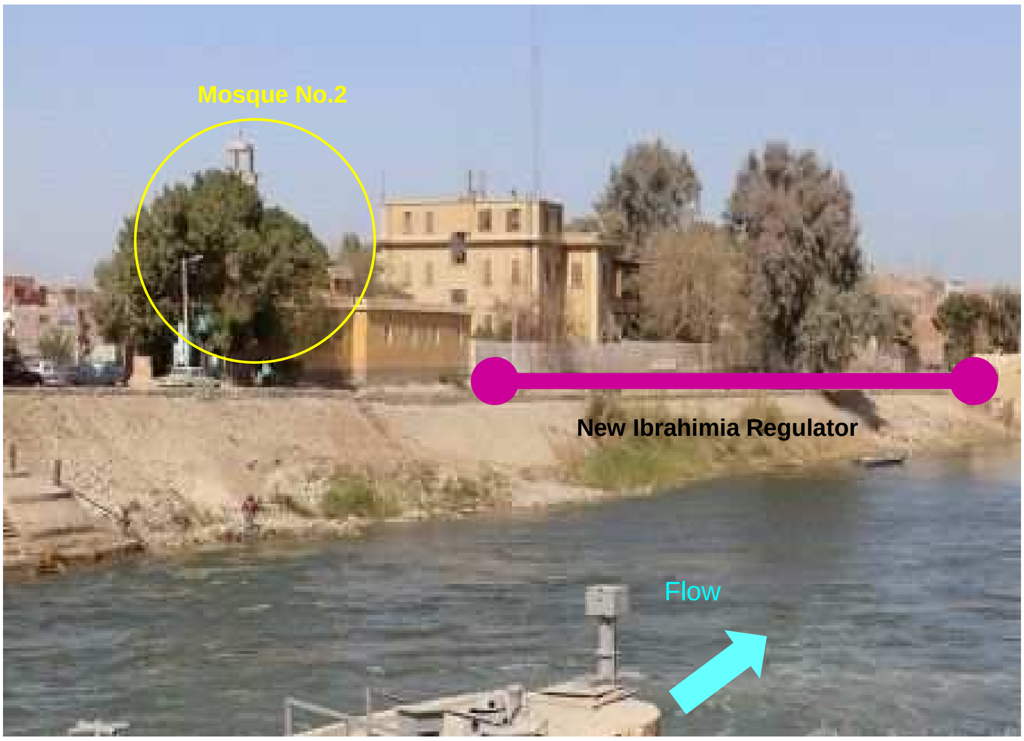
According to the law in Egypt, it is prohibited to construct any structures within the river bed, which means that there are no private lands to be affected by the project. However, there is an illegal café on upstream of Abo Gabal regulator as shown in following pictures, which was constructed after the F/S. Construction works can be done without the relocation of the café, it will be dusty and noisy for the café in the construction period, though.

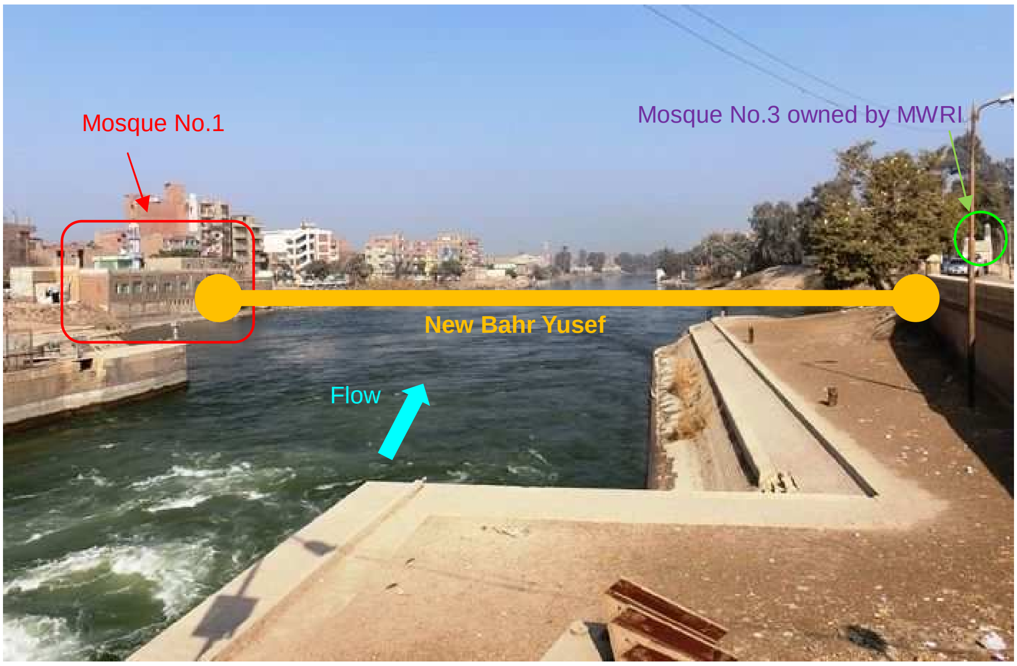

Illegal Café (view from the Bahr Yusef regulators)

Entrance of the Illegal Café (“Lawyers Club”)

There are three mosques to be affected by the construction works of the NDGRs. The Mosque No.1 and Mosque No.2 are under the management of the Ministry of Awqaf of Egypt (Ministry of Awqaf), while the Mosque No.3 belongs to the MWRI, which means under the control of

MWRI. Apart from those structures, there are no buildings to be affected by the construction works.





(2) Social Status of the Command Area

1) Population

The Project covers five Governorates, namely, Beni Suef, Minia, Assuit, Fayoum and Giza. Still, beneficial area in Assuit Governorate is very small and negligible. Based on the population data on 2014[1], the total population in the beneficiary area of DGRs is estimated to be 18.25 million inhabiting an area of 6,828 km^2. The population density is, therefore, 2,673person/km^2. This figure is equivalent to 31 times of the national average one, which means the command area is very densely populated.

The population census in 2006 showed that the urban population in the beneficiary area was 4.78 million, while the rural population was 7.3 million. Based on the same data, the numbers of households in urban and rural areas are 1.18 million and 1.59 million, respectively. The family size of the urban and rural areas is 4.0 and 4.6 person/household, respectively.

2) Living conditions

According to the UNDP Human Development Report 2010, the average GDP per capita in the five Governorates, namely, Beni Suef, Minia, Assuit, Fayoum and Giza, is 8,482 LE equivalent to around 83% of the national average (10,246 LE/person). The national unemployment rate is 8.9%, while those are 11.7% and 7% are in urban and rural areas, respectively. However, the rates in the five Governorates are much lower, from 2.9% to 6.7%. On the other hand, the national poverty rate is 21.6%, while the rates are higher in the five Governorates, from 23.0% to 41.5%.

3) Meteorological Conditions

The project area is located in northern Egypt where annual rainfall is closed to zero. In the summer season, maximum daytime temperature sometimes can exceed 50^{o}C and drop to below 25 ^{o}C during night time. In the winter season, maximum daytime temperature reaches 20^{o}C at most, and drops from 6 to 8 ^{o}C during night time. During the hot season, any measures should be taken to prevent from heart attack those involved in construction works.

In this area, there is a constant north to north-westerly wind. In April and May, however, a southeasterly sand-storm usually attacks the area. It continues for 2 to 3 days, during which cars need head light even in the daytime. According to the inhabitants, sandstorms may occur several times a year. During that time, construction works are preferably stopped.

1-3 Institutional and legal frameworks of Environmental and Social Consideration in Egypt

(1) Institutional framework

In June 1997, Ministry of Environmental was established as stated in the Presidential Decree No. 275/1997. From thereon, the new Ministry has focused on defining environmental policies, preparing the necessary plans for environmental protection and environmental development projects, and implementing initiatives within a context of sustainable development. Egyptian Environment Environmental Affairs Agency (EEAA) is the highest authority in Egypt, which is responsible for promoting and protecting the environment, and coordinating adequate responses to environmental issues.

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[1] source: CAPMAS Statistic Year Book 2014

EEAA, established by virtue of Law No.4 in 1994, is to replace the Agency established by Presidential Decree No. 631 of the year 1982, in all its rights and obligations. At present, EEAA has many missions, for instance, prepares draft laws and decrees related to protection of the environment and implements studies on the state of the environment, formulate the national plan with the projects included for the protection of the environment, and prepare budgets for necessary activity. It also takes responsibility for classification of projects (screening), review and evaluate EIA reports prepared by proponents, and approve the EIA reports. Under the CEO Deputy Chairman of EEAA, there are five sectors including Environment Management Section as illustrated in Figure 1-3.1.

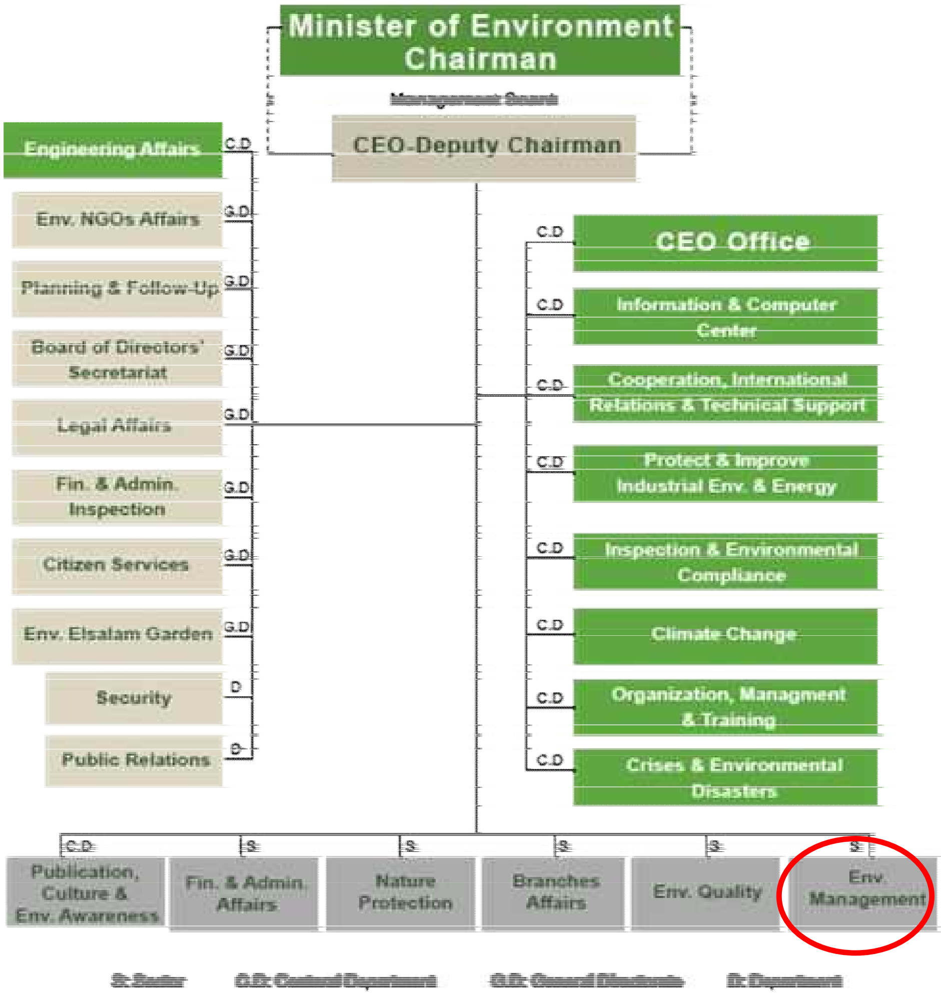


Figure 1-3.1 Organization chart of EEAA

Source: Homepage of Ministry of Environment (updated in January 2014)

EIA Central Department, under the Environmental Management Sector, is in charge of EIA review and has around 50 staff as of February 2017. There are five departments under the Central EIA Department as shown in Figure 1-3.2, Infrastructure Project Department is in charge of EIA for the project.

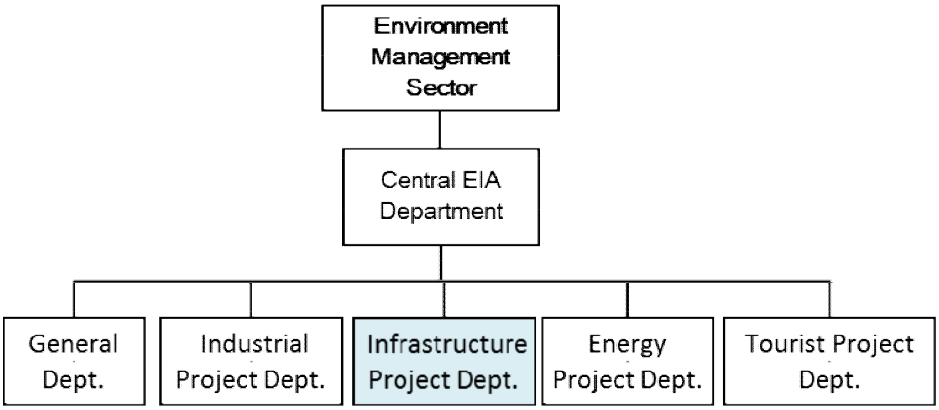


Figure 1-3.2 Departments in charge of EIA review

*Prepared through the hearing from the official personnel of Central EIA Department

(1) Legal Framework

Concerning EIA legal framework in Egypt, two main laws should be based, namely, Environmental Law No. 4, 1994, which was amended in 2009, and “Guidelines of Principles and Procedures for Environmental Impact Assessment”, in 2001, that was revised in 2009.

1) Laws, regulations and guidelines related to environmental impact assessment

Law 4 (1994, revised in 2009)

Law No. 4 states that the environmental impact of certain establishments or projects must be evaluated before any construction works are initiated or a license is issued by the competent administrative authority or licensing authority.

Guidelines of Principles and Procedures for Environmental Impact Assessment (2001, revised in 2009)

Any projects are classified into three groups or classes reflecting different levels of necessary environmental impact assessment in accordance with severity of possible environmental impact as follows:

- The "A" list projects for establishments/projects with minor environmental impact.
- The "B" list projects for establishments/projects which may result in substantial environmental impact.
- The "C" list projects for establishments/projects which require complete EIA due to their potential impacts.

The Project of NDGRs is categorized into “C” requires EIA, therefore, the EIA report of the project was prepared in 2010, and it was approved on 9th September 2010 by EEAA. More than 6 years has passed after the EIA report approval, and there is no mention to the validity period of the EIA report in any laws. Moreover, there is no statement about necessary procedures in case of modification of approved EIA reports. Therefore, the meeting with official personnel of

EEAA was held on 28th February 2017 to confirm whether the approved EIA report should be revised on.

At the meeting, it was confirmed that it is not necessary to revise the EIA report for further approval from EEAA, as far as the project location, structure, scale and so on are not changed after the approval, and the EIA Report is still valid. Moreover, it is possible to modify some parts of monitoring items depending on the current conditions in and around the regulators without obtaining the approval from EEAA again.

EIA Source Book

The EIA Source Book was published by MWRI in October 2001 for aiming at guiding the process of EIA study for any projects by MWRI. The projects are classified into 1) New irrigation projects, 2) Irrigation improvement projects, 3) Drainage projects, 4) Dams, barrages, reservoirs and flash flood projects, and 5) Shore protection projects.

2) Other laws and regulations related to environmental consideration

Law 48 (Protection of the River Nile against Pollution & Drainage of Liquid Waste, 1982)

This law aims to protect the River Nile and waterways from pollution, and to ban dumping of wastes (solid, liquid or gaseous) from ships, commercial and industrial establishments, tourism, drains and municipal waste management in streams and other water without permission of MWRI.

Law No. 10 (Expropriation of Real Estate for Public Utility, 1990)

Law No.10 deals with the expropriation for public utilities, such as, energy, water, sanitation, construction, bridges, streets and transport projects. According to the Article 6, assessment of compensation is discussed by a committee formed in each governorate, consisting of representative of the survey authority (president), and other members from each of the directorate. The compensation amount will be decided based on the market prices at the time of the expropriation decision. The land owners who are to be expropriated can get all the compensation in kind or some of it according to the agreement of the owners.

Law No. 117 (Promulgating the Antiquities' Protection Law as Amended by Law No. 3 of 2010)

According to the Article 1 of the Law No.117, any creations on the Egyptian land which has been constructed more than 100 years before are considered as antiquities. Moreover, the owners shall be liable for preservation (Article 2) and cannot renovate the characteristics without license from the Minister of Culture (Item 4 of Article 13).

Environmental Standards

The Law 4 (1994) stipulates a series of tolerance limitations, for air quality, noise/vibration and so on. Maximum permissible limitation for ambient air quality in Egypt is as shown below:

Table 1-3.1 Maximum limits of outdoor air pollutants

(Unit: microgram per cubic meter)

Pollutant	Maximum Limit	Exposure Period
Sulphur Dioxide (SO_2)	350 150 60	1 hr 24 hrs 1 year
Carbon Monoxide (CO)	30 milligrams/cubic meter 10 milligrams/cubic meter	1 hr 8 hr
Nitrogen Dioxide (NO_2)	400 150	1 hr 24 hrs
Ozone	200 120	1 hr 8 hr
Suspended Particles Measured (SPM) as Black Smokes	150 60	24 hrs 1 year
Total Suspended Particles (TSP)	230 90	24 hrs 1 year
Respirable Particles (PM 10)	70	24 hrs
Lead	1	1 year

Source: Law 4 Annex (5)

Permissible limits of sound intensity and periods of safe exposure thereto in Egypt are as shown in following table:

Table 1-3.2 Maximum permissible limits for noise intensity in the different areas

Type of Area	Intensity Decibel (A)					
	Day		Evening		Night	
	From	To	From	To	From	To
Commercial, administrative and downtown areas	55	65	50	60	45	55
Residential areas in which can be found some workshops or commercial establishments or which are located on a main road	50	60	45	55	40	50
Residential areas in the city	45	55	40	50	35	45
Residential suburbs with low traffic	40	50	35	45	30	40
Residential rural areas, hospitals and gardens	35	45	30	40	25	35
Industrial areas (heavy industries)	60	70	55	65	50	60

*Day: from 7 a.m. to 6 p.m. Evening: from 6 p.m. to 10 p.m. Night: from 10 p.m. to 7 a.m.

Source: Law 4 Annex (6)

There are various water quality standards in Egypt depending on the environmental situations and project components. Given that the project can discharge mud water into the downstream in the canals in the construction stage, “Regulations, Standards and Specifications regarding the Draining of Processed Liquid Wastes into Waterways” of Article 60 in Law 48 is to be applied as the permissible surface water quality limitation. The maximum permissible limits are shown in following table:

Table 1-3.3 Maximum permissible limits for drained water quality into fresh water body

Statement	Standards and Specifications (milligram/liter unless otherwise mentioned)
Color	<100 degrees
Total Suspended Solid	<500 mg/l
Temperature	Five degrees above the average
DO (Dissolved Oxygen)	>5 mg/l
pH	7-8.5
BOD (Biological Oxygen Demand)	<6 mg/l
COD (Chemical Oxygen Demand)	<10 mg/l
Organic nitrogen	<1 mg/l
Ammonia	<0.5 mg/l
Grease and oils	<0.1 mg/l

Regarding water quality of groundwater, considering that some people use the groundwater for drinking in Dirout city, “Egyptian Standards for Drinking Water 2007” can be applied for the project. The maximum permissible level for drinking water is as shown below:

Table 1-3.4 Maximum permissible limits for drinking water

[General Specification]

Parameter	Minimum Permissible Limit	Maximum Permissible Limit
Color by cobalt platinum method	10 units	50 units
Turbidity by Jackson Candle method	5 units	25 units

[Chemical specification]

Parameter	Maximum Permissible Limit
Lead	0.05 mg/l
Selenium	0.2 mg/l
Arsenic	0.05 mg/l
Hexavalent chromium	0.01 mg/l
Fluoride	5 mg/l
Nitrates	40 mg/l

[Chemicals that affect the validity of the use of water]

Parameter	Minimum Permissible Limit	Maximum Permissible Limit
Dissolved solid	500 mg/l	1200 mg/l
Iron	0.3 mg/l	1 mg/l
Manganese	0.1 mg/l	1 mg/l
Copper	1 mg/l	1.5 mg/l
Zinc	5 mg/l	15 mg/l
Magnesium	50 mg/l	150 mg/l
Calcium	75 mg/l	200 mg/l
Sulphate	200 mg/l	400 mg/l
Chlorides	200 mg/l	600 mg/l
pH	7-8.5	6.5-9.2
Phenolic compounds	0.001 mg/l	0.002 mg/l

Bacteriological properties:

- It must not exceed the total coli in sterile water for 1/100ml
- It must not exceed the total coli in untreated water for 10/100ml

1-4 Examination of alternatives

Alternative plans for the location of new regulators were examined and evaluated. The alternative plans consist of: Plan-A (rehabilitation of the existing regulators at the original alignment); Plan-B (new regulator at upstream); and Plan-C (new regulators at downstream) as illustrated in Figure 1-4.1. As the examination result is shown in Table 1-4.1, Plan –C has the highest score among the alternatives in terms of various factors including cost, technical difficulties, stability and so on.

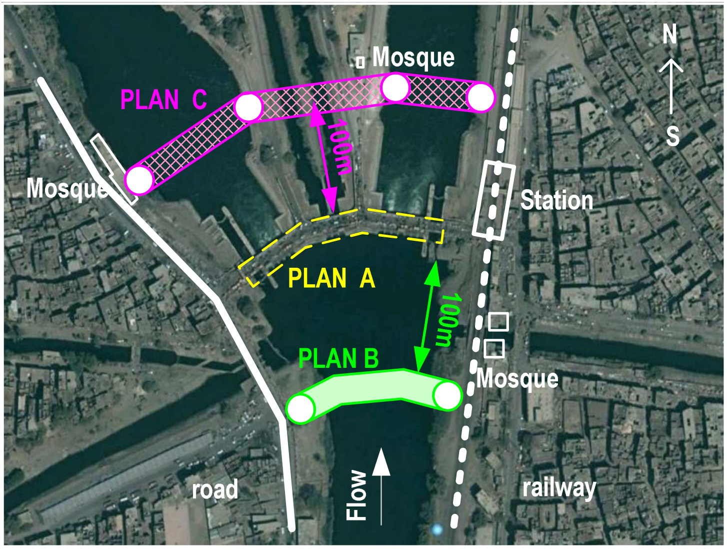


Figure 1-4.1 Preliminary layout of NDGRs' axis

Table 1-4.1 Examination of the alternative plans

Item	Plan-A	Plan-B	Plan-C
Hydraulic Performance	1	2	3
Stability of Structure	1	3	3
Ease of Construction	1	1	3
Operation & Maintenance	1	3	3
Heritage and View	1	1	2
Environmental	3	2	1
Comprehensive Evaluation	**8**	**12**	**15**
Working Life	40 yrs	100 yrs	100 yrs
Navigation Lock	Existing	Not possible	Possible
Hydropower Plant	Not possible	Not possible	Possible

Evaluation Category; 1:Low、2:Medium、3:High

The examination of three alternatives in view of environmental and social consideration is as shown in Table 1-4.2. Plan-A gets the highest scores in terms of that point, while Plan-C gets the highest scores for the other factors (engineering, project life and the rest). Taking into consideration various conditions, Plan-C was finally selected.

Table 1-4.2 Comparison of alternative plans for Environmental and Social Considerations

Item	Plan A	Plan B	Plan C
Heritage and View	In case of electrifying the existing gates, installation of switching devices on the existing structures will spoil the landscape of DGR. **Point:+1**	Since the new regulators are constructed at the upstream side and feeder canals are constructed from the new regulators to the existing DGR, the landscape of the upstream side of DGR will be drastically changed. **Point:+1**	Because the new regulators are constructed at the downstream side, the view of the downstream side of the existing DGR will be changed. **Point:+2**
Environment	There will be no land acquisition or relocation of houses/structures. **Point:+3**	There will be no land acquisition or relocation of houses/structures. However, if hydro-power plant and navigation lock are to be constructed, land acquisition for those facilities is necessary. **Point:+2**	There is a mosque on the left bank of Bahr Yusef. This mosque is requested to relocate in construction work **Point:+1**

2. Review of Environmental Impact Assessment

The EIA report on the project, which has been approved on 9th September 2010 by EEAA, was reviewed taking into consideration current conditions, focusing on mainly the environmental evaluation, environmental management plan and environmental monitoring plan. Environmental WG under the RGBS also participated in the process. Moreover, present progress of environmental monitoring as of February 2017 was also confirmed through discussion with ECRI which was in charge of the EIA report preparation in 2010.

2-1 Change of environmental conditions after the F/S

Given that there are some environmental changes in and around the construction sites between 2010 and 2016, it is needed to review the EIA report.

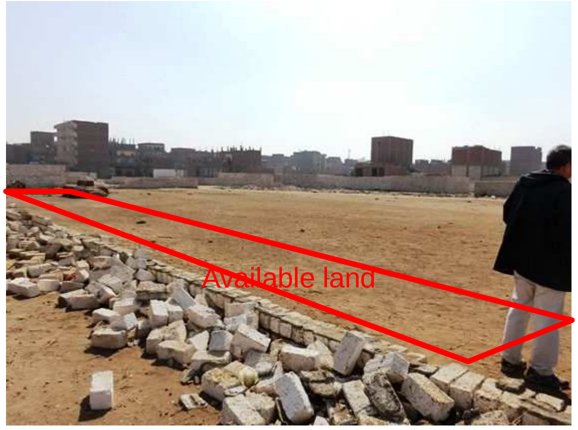
“JICA Guidelines for Environmental and Social Considerations” (hereinafter referred as to “JICA Guidelines”) was revised in April 2010, and the new one mentions the necessity to minimize deviation between the international standards and laws of the recipient counties, if there is a significantly big gap. In Egypt, it is not necessary to provide compensation to illegal occupants/residents, if involuntary resettlement and land acquisition are caused and affected persons are illegal, there is a gap between the JICA Guidelines and Egyptian laws. On the other hand, there is no change of laws/regulations related to EIA and environmental standards in Egypt since 2010.

The largest changes in Egypt are democratization in 2011 and introduction of floating rate system in 2016 after the approval of the EIA report in September 2010. However, they are political and economic change, and not natural, industrial and demographic change in and around DGRs. Agriculture is still an important industry for the command area.

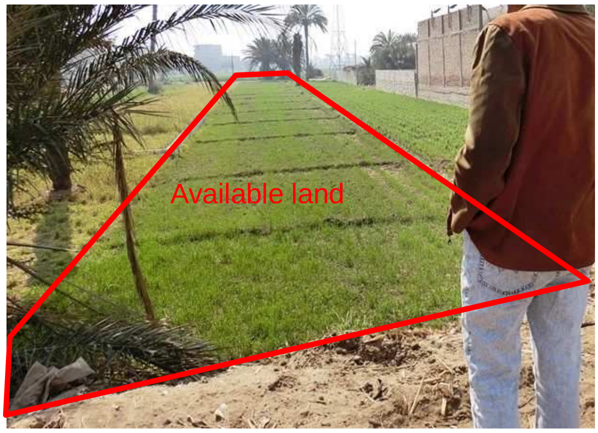
There are some minor changes of the surrounding conditions, such as construction of illegal café within the dry river bed at just upstream of the regulators, which refuses relocation for the project. Still, the construction works nearby the café can be implemented without the relocation; impacts such as dust and noise/vibration for the café are expected, though.

Concerning relocation of mosques, in the Minutes of Discussion (M/D) of this Loan, three mosques of them should be relocated to other sites, prior to the construction works. Parts of area around the construction sites, namely, spaces between Bahr Yusef Canal and Badraman canal, and Diroutiah canal and Ibrahimia canal, belong to the MWRI. Therefore, those three mosques can be shifted to neighboring areas as shown in Figure 2-1.1.

Originally, it was planned to set the stockyard including the batcher plant in the farmland 2-3 km upstream of the regulators at F/S stage. However, the farmland cannot be leased, since the consensus on the compensation rate with the land owners has not been obtained. Instead of that, the batcher plant will be constructed within the land owned by MWRI just downstream of the NDGRs. However, it is needed to secure additional site for the temporary stockyard, around 1 feddan (=0.42ha) for two years at longest. There are some available lands that the owners have willingness to rent, which are not far from the DGRs (see photos below). MWRI has a plan to apply bidding system for the land tenancy for the temporary yard. Based on the contract to be exchanged between MWRI and the land owner, the rental fee shall be paid, the rate has yet to be fixed, though.



Candidate for stockyard (1): app. 0.5ha
around 0.5km away from the construction site
Land is not used for any purposes as of Feb 2017.



Candidate for stockyard (2): app. 0.4ha
around 1 km away from the construction site
Land is used as a farmland as of Feb. 2017.

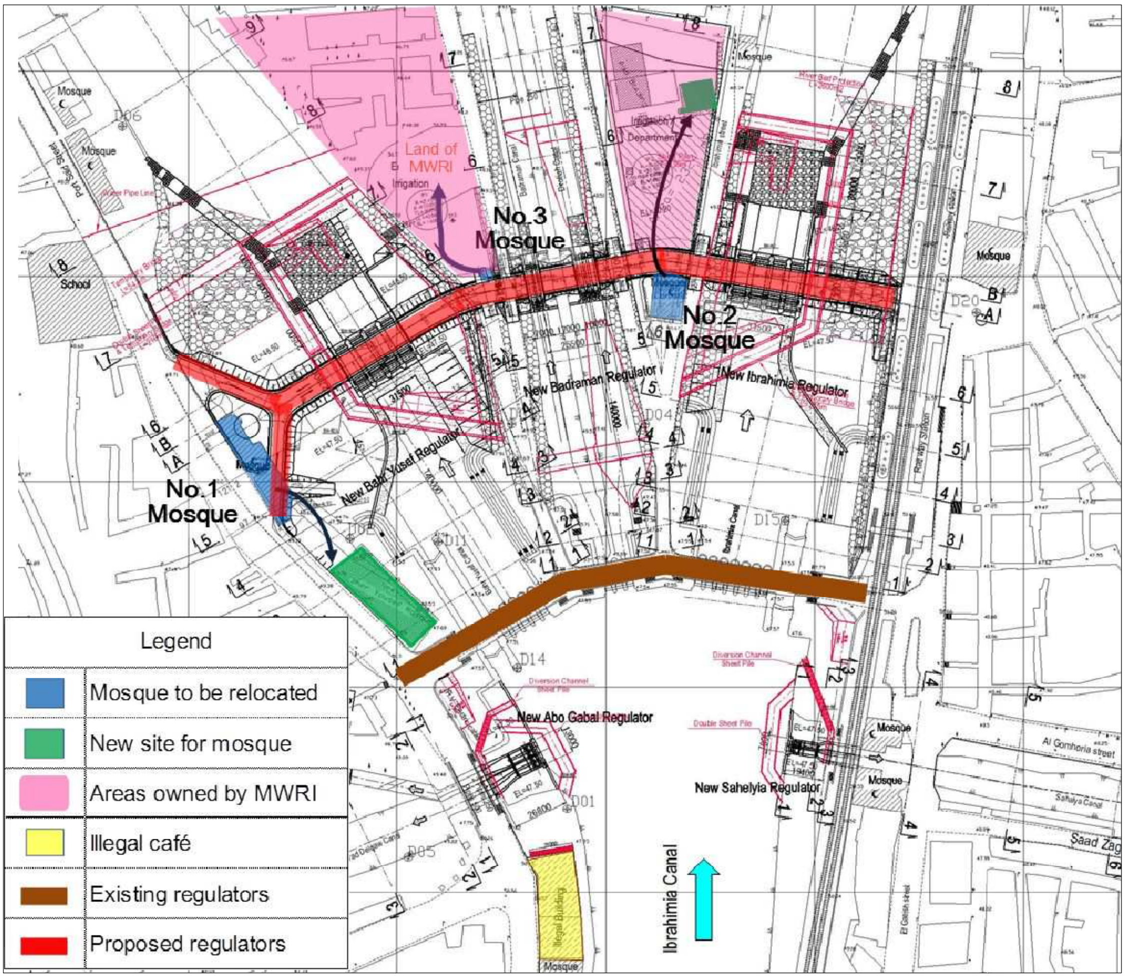


Figure 2-1.1 Location of mosques to be relocated and illegal café around the regulators

2-2 Progress of Environmental Management Plan and Environmental Monitoring Plan

The EIA report, which was approved by EEAA, stipulates environmental monitoring items for pre-construction stage, construction stage and operation stage. 16 items[2] including surface water quality, land use, noise, vibration, health, waste, growth of weed and so on are listed up as items. Actually, groundwater quality check and groundwater level measurement have been implemented in D/D stage, while other items have not been done. Moreover, it is not clear which organization is responsible for the monitoring, especially for pre-construction stage in the EIA Report. Therefore, this point was discussed at the 25th TAC meeting on 20th February 2017, and it was agreed that the S/V consultant will be responsible for the monitoring in pre-construction stage.

According to the official personnel of EEAA, it is surely needed to monitor groundwater level and groundwater quality according to the recommendation in the letter which approved the

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[2] Air emission is not listed up as one of monitoring items for pre-construction stage in the EIA Report. However, given that air pollution should be monitored in the construction stage, it is recommended to implement monitor air emission even pre-construction stage.

EIA report by the EEAA. On the other hand, if other monitoring items are judged as unpractical, it is possible to skip or change such items as far as the reasons are clearly mentioned in the motoring report. Moreover, it is not needed to take any procedures to get approval of the EIA report again.

Based on the consensus mentioned above, the existing Environmental Management Plan and Environmental Monitoring Plan are revised (refer to chapter 2-4).

2-3 Monitoring results of groundwater level and water quality check

The canal water level between DGRs and NDGRs will rise up to 2m after the construction of NDGRs. Moreover, canal water level will be controlled on EL.46.3m whereas the current maximum water level is approximately EL.46.0m. Those changes in canal water level will affect the groundwater head around those areas. As the current condition, some basements of houses located near the DGRs, have already shown signs of seepage; therefore, it is necessary to grasp the extent of the negative impact on those seepages. Moreover, groundwater is still utilized as the drinking water in some areas, when the tap water system is cut off; so that the impact on the groundwater quality also should be carefully assessed.

Groundwater monitoring aiming at recording the baseline of the hydrological data was carried out two to three times per month at thirteen piezometers from October 2015 to April 2017 for groundwater head and its quality (EC, pH and DO), and two times at two points (BH-N7 and BH-N10 beside the new axis line) for the detailed water quality test (refer to Figure 2-3.1). The detailed result of the groundwater monitoring is attached in the Appendix.

(1) Groundwater head

Groundwater head increased from June to August when the water demand is highest (the shallowest water level from the surface ground was 1.75m), and compared with the peak level, it decreased by 2.2m to 2.3m during the winter closure which shows the lowest canal water level. Those changes clearly indicate the groundwater head will correspond to the surface water level (refer to Figure 2.3-2 and Table 2-3.1).

Moreover, the aquifer can be partly recharged by the surface water because the groundwater head was basically higher at the piezometers close to the canals than the other piezometers, which also indicate the rise in canal water level will have the negative impact on the groundwater head (evaluation of the mitigation measures for the rise in groundwater head is discussed in the “Volume I Design of Regulators, ‘Chapter 20. Groundwater Simulation Analysis’).

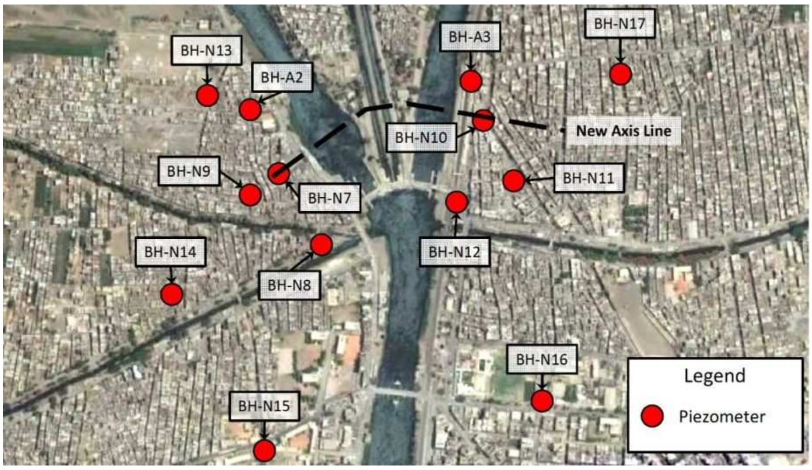

Figure 2-3.1 Location of the piezometers

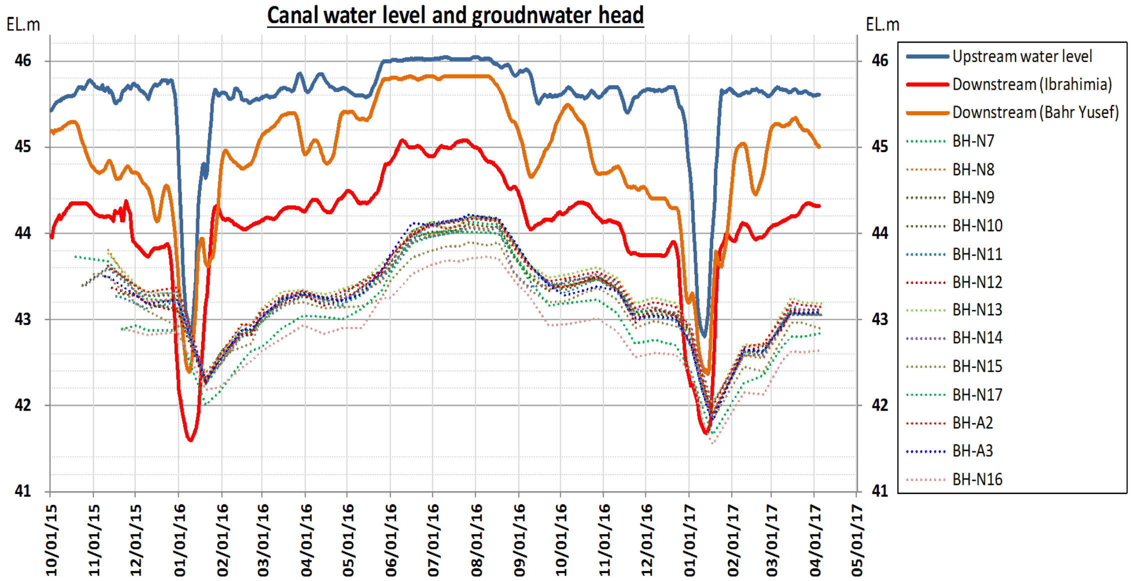

Figure 2-3.2 Seasonal change of groundwater head and canal water level
(Oct. 2015-Apr. 2017)

Table 2-3.1 Maximum/Minimum Groundwater Level/Depth (Oct. 2015- Apr.2017)

Monitoring Well / Canal	Max. Depth (m)	Min. WL (EL.m)	date		Min. Depth (m)	Max. WL (EL.m)	date
BH-N7	5.38	41.93	18/1/2017	～	3.17	44.14	27/7/2016
BH-N8	5.62	41.93	18/1/2017	～	3.46	44.09	17/8/2016
BH-N9	5.06	41.88	18/1/2017	～	2.83	44.11	27/7/2016
BH-N10	6.88	41.88	18/1/2017	～	4.56	44.20	27/7/2016
BH-N11	5.64	41.89	18/1/2017	～	3.34	44.19	27/7/2016
BH-N12	8.82	41.90	18/1/2017	～	6.54	44.18	27/7/2016
BH-N13	3.93	42.02	18/1/2017	～	1.75	44.20	27/7/2016
BH-N14	4.81	42.03	18/1/2017	～	2.77	44.07	17/8/2016
BH-N15	4.96	41.84	18/1/2017	～	2.90	43.90	10/8/2016
BH-N16	4.78	41.55	18/1/2017	～	2.60	43.71	10/8/2016
BH-N17	4.83	41.66	18/1/2017	～	2.47	44.02	27/7/2016
BH-A2	5.00	42.00	18/1/2017	～	2.83	44.17	27/7/2016
BH-A3	7.56	41.83	18/1/2017	～	5.17	44.22	27/7/2016
U/S Ibrahimia	-	46.08	23/6/2016	～	-	42.65	12/1/2016
D/S Ibrahimia	-	45.13	11/6/2016	～	-	41.60	12/1/2016
D/S Bahr Yusef	-	45.82	16/6/2016	～	-	42.17	18/1/2017

(2) Groundwater Quality

Figure 2-3.3 to Figure 2-3.5 show the trend of the groundwater quality. It can be evaluated that the impact on change of water level does not have direct relation with water quality, considering that the groundwater quality were not changed very much between the highest (Irrigation Season) and lowest (Winter Closure) water level periods. In regard to the Electric Conductivity, abrupt change was observed at certain sampling points and dates, which seems to be caused by the sewage intrusion to the aquifer. Figure 2-3.6 shows the EC values around Dirout, giving the followings; 1) high EC values were observed in the town area, and 2) low EC values on the right bank of the Ibrahimia regulator. Those facts indicate 1) sewage intrusion from the resident area, and 2) aquifer recharge from the canal water[3] on the right bank of the Ibrahimia regulator.

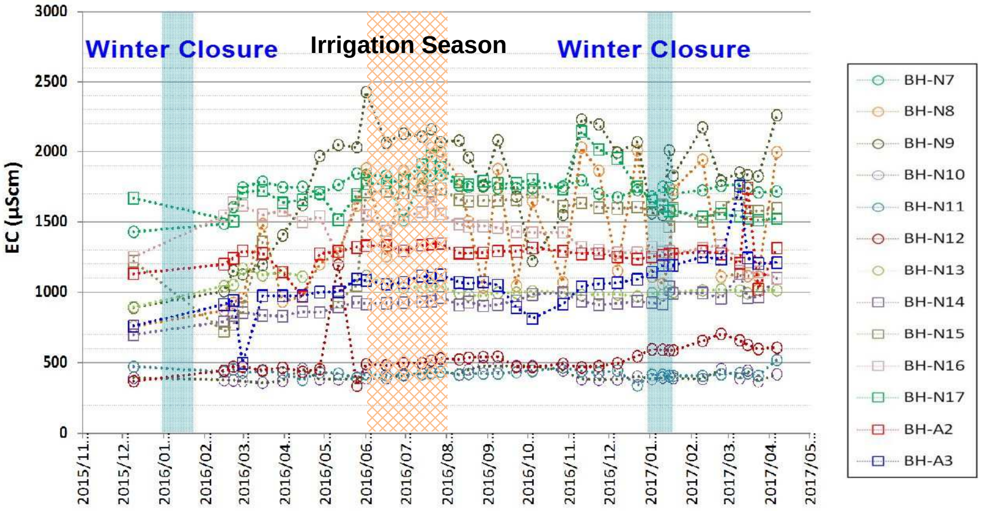

Figure 2-3.3 Seasonal Change of EC (Nov 2015-Apr.2017)

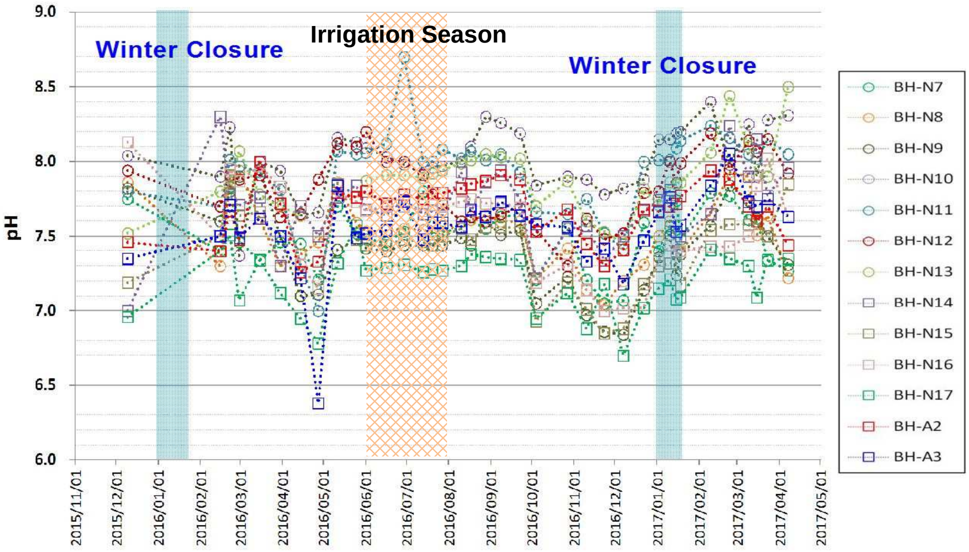

Figure 2-3.4 Seasonal Change of pH (Nov.2015-Apr.2017)

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[3] EC of the canal water is approximately 300µS/cm, showing distinct difference in EC value of groundwater (1,000 to 2,000µS/cm)

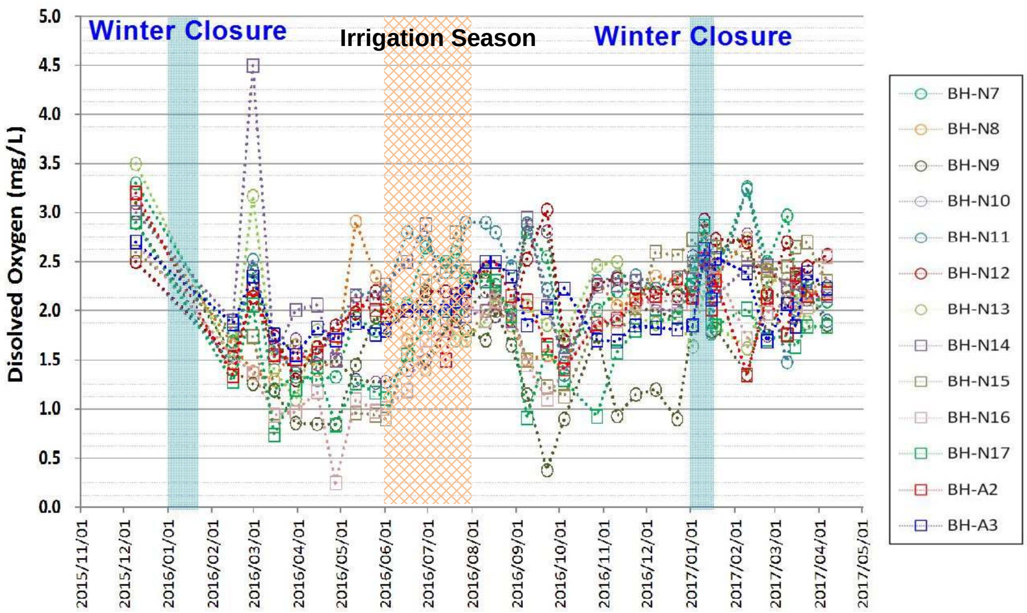

Figure 2-3.5 Seasonal Change of DO (Nov.2015-Apr.2017)

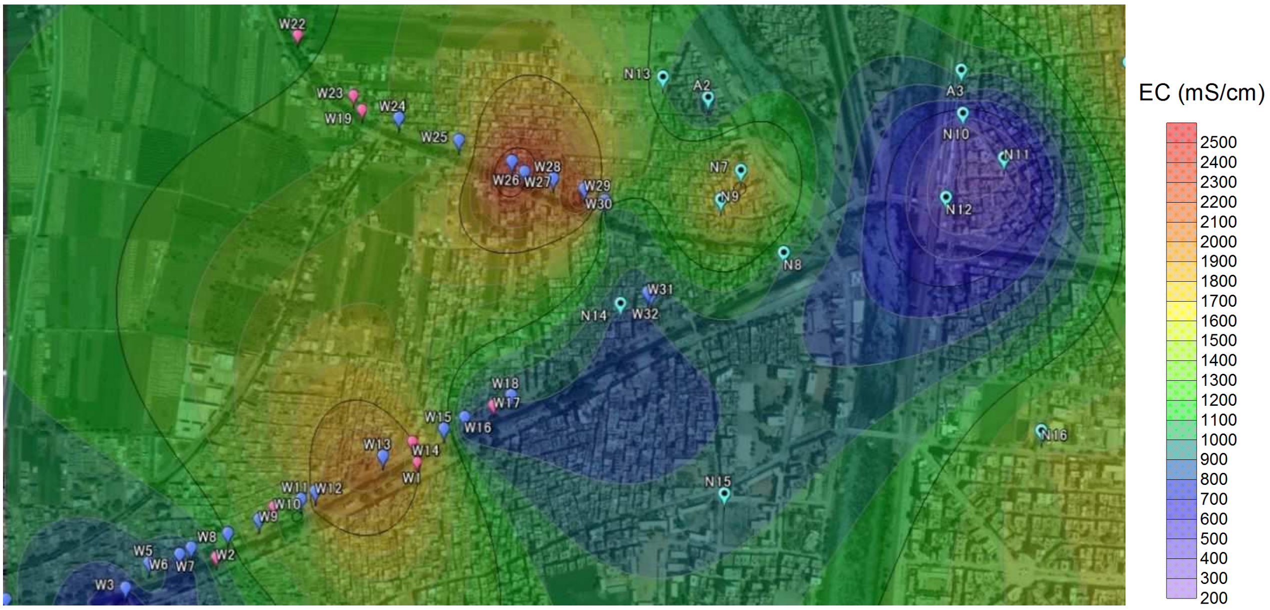

Figure 2-3.6 EC distribution trend (14th April 2016)

※Balloon symbols with W in the figure show the location of the hand pump well found by the inventory survey

Table 2-3.2 shows the result of the detailed water quality test at two sampling points (BH-N7 and BH-N10). Compared to the Egyptian standards for the drinking water, total (fecal) coliform and the excessive concentration of the manganese ion were detected. At BH-N7 (the left bank of the Bahr Yusef regulator), high concentrations of sodium and chloride ions were also detected, which can be considered as the sewage origin. The existence of the Sulfur which gives unpleasant odor to the groundwater was also identified, which also indicates aquifer is in a reduced state.

Given that those all results are seemingly caused by the sewage water, it is difficult to improve the groundwater quality unless the current sewage treatment system is improved. Therefore, not only from the aspect of prevention measures of the seepage, but also the aspect of the groundwater quality, the improvement in the sewage water treatment system is essential.

Table 2-3.2 Results of groundwater quality check

Item		Unit	Egyptian Standard*	BH-N7		BH-N10		Remarks
				13 Jul. 2016	2 Jan. 2017	13 Jul. 2016	2 Jan. 2017	
Physical & Chemical Property								
1	Temperature	°C	-	25.0	23.5	24.6	22.9	-
2	pH	-	6.5 - 8.5	8.0	7.4	8.0	8.2	-
3	EC	mS/cm	-	1.714	1.68	0.424	0.383	Electiric Conductivity
4	Turbidity	NTU	1	5	8	13	3	-
5	TDS	mg/L	1000	1098	1175	271	258	Total Dissolved Solids
6	TSS	mg/L	-	2	3	2	3	Total Suspended Solids
7	COD	mg/L	-	110	138	40	53	Chemical Oxygen Demand
8	BOD	mg/L	-	160	200	63	80	Biological Oxygen Demand
9-1	CO_3	mg/L	-	0	0	0	0	Carbonate
9-2	HCO_3	mg/L	-	574	220	178	138	Bicarbonate
10	TA	mg/L	-	574	220	178	138	Total Alcalinity
Hydro-checmial Property								
11	Ca	mg/L	200	103	120	34	31	Calcium
12	Mg	mg/L	150	38	17	11	10	Magnesium
13	Na	mg/L	200	220	200	35	28	Sodium
14	K	mg/L	-	12	16	4	6	Potassium
15	Cl	mg/L	250	269	265	28	21	Chloride
16	SO_4	mg/L	250	20	210	13	21	Sulfate
Trace Element & Heavy Minerals								
17	NO_3	mg/L	44	0.71	0.3	3.47	< 0.2	Nitrate
18	NO_2	mg/L	0.02	< 0.2	< 0.2	0.91	< 0.2	Nitrite
19	PO_4	mg/L	-	< 0.2	< 0.2	< 0.2	< 0.2	Phosphate
20	S	mg/L	-	6.81	70	4.24	7	Sulfur
21	Cr	mg/L	0.050	0.001	0.004	0.001	< 0.001	Chromium
22	Cu	mg/L	2.0	0.031	0.020	0.027	0.015	Copper
23	Fe	mg/L	0.3	0.080	0.162	0.054	0.119	Iron
24	Mn	mg/L	0.4	0.163	1.515	0.238	0.445	Manganese
25	Ni	mg/L	-	0.033	0.012	0.004	< 0.001	Nickel
26	Pb	mg/L	0.01	< 0.001	< 0.001	< 0.001	< 0.001	Lead
27	Zn	mg/L	5.0	0.010	0.013	0.004	0.005	Zinc
Others								
-	Total Coliform	CFU/100ml	N/D	1.4E+05	4.4E+03	5.0E+04	1.2E+03	-
-	Fecal Coliform	CFU/100ml	N/D	2.0E+05	N/D	2.0E+04	N/D	-

* Egypt Standards according to the Minister of Health decree Number (108) for 1995 and (458) for 2007

2-4 Review of environmental evaluation

As mentioned before, it is not necessary to drastically modify the environmental evaluation of the EIA Report, which has been prepared at F/S stage, since there is no significant change in terms of environmental conditions in and around the regulators. Therefore, parts of description in the environmental evaluation were revised as shown in Table 2-4.1.

As for "No.5 Groundwater level" was described as "Groundwater quality" in the original report. However, it pays attention to rise of groundwater level, thus, the title is changed to "Groundwater level", and "Groundwater quality" is newly added as No.6. Concerning "No.9 Land use and land tenure", description of "reasons" is changed based on the current conditions. As for "No.18 Odor", original evaluation was B, however, it is not caused by the Project, and it is re-evaluated as D. Moreover, regarding "No.17 Safety of the regulators", it is possible to prevent from water inflow to the construction site by installation of sheet piles, which leads to no damage to soil and the regulators. Therefore, the evaluation for the item is also changed into D. The revised Environmental Evaluation is as shown below:

Table 2-4.1 Revised environmental evaluation

No	Items	Evaluation		Reasons
		Construction Stage	Operation Stage	
1	Topography and geology	D	D	The project scale is not very large to affect topographic and geological conditions.
2	Weather and climate	D	D	The Project does not cause any changes of weather and climate.
3	Air Emission	B	F	Construction stage Due to increase of vehicle numbers for the construction works, dust can be generated. Moreover, the batcher plant which processes concrete materials will generate powder dust. However, such situations are limited to only construction stage. Operation stage No air pollution is expected after the completion.
4	Surface Water Quality	B	D	Construction stage Effluent containing cement can be discharged from the batcher plant, and oil might get out of. Operation stage No effect of water quality is expected in operation period.
5	Groundwater Level	B	B	Construction stage Groundwater level can be increased by the construction works, however, it is acceptable level, which does not give damage to existing structures considering the groundwater level simulation result. Operation stage Groundwater level can be increased after completion of the construction works, however, it is acceptable level, which does not give damage to existing structures based on the groundwater simulation result.
6	Groundwater Quality	C	C	Construction stage According to the groundwater quality monitoring, sewage seems to intrude to groundwater. Since parts of people in

No	Items	Evaluation		Reasons
		Construction Stage	Operation Stage	
				Dirout city use groundwater as drinking water, it is needed to monitor groundwater quality continuously. Still, current issue is caused by improper sewage treatment system, and it is thought that the Project will not cause water quality deterioration directly. Operation stage As the same in the construction stage, continuous water quality check is necessary.
7	Water Flow and River Morphology	B	D	Construction stage Due to setting of the temporary cofferdam in the canals, water flow can be changed to some extent, however, the same water discharge will be kept for irrigation in downstream, and the period is limited to the construction period. Operation stage After the completion of construction works, no impact on the water flow is expected.
8	Archeological Treasure	D	D	It is proposed to preserve the current DRG as a historical monument and main structure of the DRG will not be spoiled. Therefore, the construction works does not give damage to the antiquities.
9	Land Use and Land Tenure	B	D	Construction stage It is needed to lease land for temporary stockyard from some private land owners under the contract after the bidding. In case of lease of farmland, the land shall be recovered to the original condition after the construction works. It is, thus, needed to avoid lease of farmland as much as possible. Operation stage After the completion of works, no impact is expected.
10	Fishery	B	D	Construction stage Fishermen who have license for fishing around the regulators have not been identified. In addition, due to the effluent containing cement from the batcher plant, fish larvae, benthic organism and planktons can be affected. However, a sedimentation pond at the plant can minimize the issue, and the impacts on the fishery will be very limited. In case there are any complaints by fishermen, RGBS staff in Dirout will receive and handle the complaints. Operation stage After the completion of works, no impact is expected.
11	Income	F	F	Construction stage The construction works will create the new job opportunities (e.g. restaurant, cafeteria, etc.), which will increase the income of some citizens, as well as workers coming from nearby villages. Operation stage After the completion of works, stable irrigation water can be supplied to the command area, which leads to income improvement of the beneficiaries.
12	Access to the	B	D	Construction stage

No	Items	Evaluation		Reasons
		Construction Stage	Operation Stage	
	Project Site			Transportation of the construction material by heavy machines might cause traffic jam. Operation stage After the completion of works, traffic jam by the NDGR is not expected.
13	Noise	B	D	Construction stage Using heavy equipment and increase of vehicle numbers may generate noise, however, it is temporary. Operation stage After the completion of works, noise is not expected.
14	Vibration	B	D	Construction stage Vibrations can be caused by the sheet pile installation and movements of heavy machines. However, it is limited to only construction stage. Operation stage After the completion of works, vibration is not expected.
15	Health and safety	B	D	Construction stage Accident by the construction works, traffic accident and infectious diseases can be caused due to use of construction vehicles, increase of number of vehicles and employment of many workers. Operation stage After the completion of works, no health and safety issue by the NDGR Project is expected.
16	Labor accommodation camps	D	D	No accommodation camp for the labors is to be constructed, since they will come from nearby villages.
17	Safety of the regulators	D	D	Construction stage A temporary cofferdam will be put by using of sheet piles, which prevents from water inflow. In such case, any damages to on soil and the regulators are not given. Operation stage After the completion of works, no impact on the safety of the regulators is expected.
18	Odor	D	D	The odor may be caused by accumulated algae and dead animals in the water ways. However, the odor is not generated by the construction works.
19	Sediment	D	D	A large quantity of sediment is not expected, since dredging is carried out regularly as a routine work.
20	Solid Waste	B	D	Construction stage Wastes materials are generated by the construction activities. Therefore, it is needed to Operation stage No impact is expected in operation stage.

Evaluation category:
A: Serious impact is expected
B: Some impact is expected
C: Extent of impact is unknown
D: No impact is expected. EIA is not necessary
F: Positive impact
*Highlighted cells show that negative impacts are expected in the parameters.

3. Environmental Management Plan and Monitoring

3-1 Environmental Management Plan and Cost

Based on the revised Environmental Evaluation discussed above, the original EMP in the EIA Report is also revised as shown in Table 3-1.1. The table shows mitigation measures for the items respectively which are evaluated as “B” and “C” in Table 2-4.1. Moreover, the mitigation cost is included in the construction cost in the construction stage in general, while the cost in operation stage is covered by the MWRI.

Table 3-1.1 Environmental Management Plan

No *1	Environmental Items	Mitigation measure	Implementation agency	Responsible agency	Cost
Pre-construction stage					
9	Land use and Land tenure	● To exchange land lease agreement on the temporary yard ● To avoid lease of farmland as much as possible since it is needed to recover the farmland to the original condition	MWRI*2	MWRI	Budget of MWRI*2
Construction stage					
3	Air Emission*3	● Installation of a dust extractor at the batcher plant ● Water spray around the construction site ● Regular maintenance of construction vehicles	Contractor	MWRI	Included in construction cost
4	Surface Water Quality	● Set-up of a sedimentation basin at the concrete batcher plant to prevent effluent containing cement from discharging to the downstream	Contractor	MWRI	Included in construction cost
5	Groundwater Level	● Regular monitoring of groundwater level	Contractor	MWRI	Included in construction cost
6	Groundwater quality	● Regular monitoring of groundwater quality ● Improvement of existing sewage system	Contractor Holding Company for Water & Waste water (HCWW)	MWRI MWRI	Included in construction cost Regular budget of HCWW
7	Water flow and river morphology	● Keeping the same discharge to the downstream as planned	Contractor	MWRI	Included in construction cost
9	Land use and land tenure	● Whether payment to the land owners has been done should be confirmed	MWRI*2	MWRI	Budget of MWRI*2
10	Fishery	● Setting of sedimentation basin at the concrete batcher plant to prevent effluent water to downstream ● Employ persons with high priority who depend on fishery for livelihood	Contractor	MWRI	Included in construction cost
12	Access to the Project Site	● Preparation of a vehicle operation schedule which deconcentrates utilization of vehicle	Contractor	MWRI	Included in construction cost
13	Noise	● To refrain from the construction works at night in the residential areas as much as	Contractor	MWRI	Included in construction

No *1	Environmental Items	Mitigation measure	Implementation agency	Responsible agency	Cost
		possible ● Silent piler machine is to be used for piling to minimize noise around densely populated area and railway while hydraulic hammer is used in other areas			cost
14	Vibration	● To refrain from the construction works at night in the residential areas as much as possible ● Silent piler machine is used for piling to minimize noise around densely populated area and railway while hydraulic hammer is used in other areas	Contractor	MWRI	Included in construction cost
15	Health and safety	● Paying attention to the workers' health condition, and if there is a possibility of incident of infectious diseases taking place, immediately inform the Ministry of Health. ● Request the Ministry of Health to carry out awareness creation on HIV/AIDS among the workers and recommend them to voluntary check the status of HIV/AIDS. ● To identify if there is too tight operation schedule or not, and if so rectify it. ● Place traffic control staff along the construction roads. ● To explain contents of the work to the workers with necessary care taking for their safety prior to the start of the work, and make daily confirming safe meeting before starting the work.	Contractor	MWRI	Included in construction cost
20	Solid waste	● Re-use excavated soils ● Disposal of waste generated from the construction site to the dumping site.	Contractor	MWRI	Included in construction cost
Operation stage					
5	Groundwater Level	● Monitoring of groundwater level	MWRI	MWRI	Included in regular budget of MWRI
6	Groundwater quality	● Monitoring of groundwater quality	MWRI	MWRI	Included in regular budget of MWRI

*1: Numbers in the table are the same ones which hare illustrated in Table 2-4.1.

*2: It is tentatively set as MWRI, however, it is to be discussed at biding and contract exchange.

*3: It is newly added as an environmental item, since EEAA recommended monitoring groundwater quality in 2010.

3-2 Environmental Monitoring Plan

As mentioned before, it is needed to re-examine existing monitoring items and to propose a new monitoring plan depending on the current conditions. Regarding "groundwater quality", it will not be influenced by the project; however, considering that high concentration of chloride, sodium, manganese were detected in the groundwater as mentioned in Table 2-3.2 and EEAA recommends to monitor the groundwater quality, this item is also included. The revised monitoring items by stage are as shown in from Table 3-2.1 to Table 3-2.3.

Table 3-2.1 Environmental monitoring items for pre-construction stage

（to be covered by the S/V Consultant）

Items (proposed in the EIA Report)	Decision of implementation	Reasons
1. Air emission	To be implemented	Air emission is not included in the monitoring items in the EIA Report. However, it is needed to include the item, since air pollution is expected in the construction period.
2. Surface water quality	To be implemented as planned	
3. Groundwater quality	To be implemented as planned	
4. Groundwater level	To be implemented as planned	
5. Noise	To be implemented as planned	
6. Vibration	To be implemented as planned	
7. Water flow and river morphology	Not to be implemented	Due to cofferdam, conditions of water flow would be changed, however, the same amount of water discharge to the downstream is kept, which will not result in damage to the farming in the downstream. Moreover, it is difficult to evaluate the change quantitatively.
8. Land use and land tenure	Progress of contract exchange of the 1) land lease and 2) transfer of mosques which are under control of the Ministry of Awqaf is to be checked.	
9. Fishery	Number of fishermen and legalities of them shall be identified.	
10. Income	Not to be implemented	Since negative impacts on incomes of neighboring people and beneficial farmers are not expected, monitoring of income is not necessary.
11. Access to the Project Site	Not to be implemented	There is no quantitative regulation/standard related to transportation, and monitoring of transportation is not necessary. Moreover, since there are no limitation of number of vehicles in the roads, “access to the Project site” cannot be assessed. It is noted that an operation schedule of construction vehicle should be prepared to avoid traffic jam in construction stage.
12. Health and safety	Not to be implemented	Since there is no infectious diseases or accidents before construction works, monitoring of the item is not needed.
13. Safety of regulators	Not to be implemented	Cofferdam is put by using pile sheets, and such construction works will not cause damage to the existing regulators. It is, thus, not necessary to monitor the safety, especially in pre-construction stage.
14. Solid waste	Not to be implemented	Since no waste is generated before construction works and quantitative measurement is difficult, monitoring of waste is not implemented.
15. Odor	Not to be implemented	Regardless of implementation of construction works, dead animal and solid waste are thrown

Items (proposed in the EIA Report)	Decision of implementation	Reasons
		away to the canal, which does not have direct relationship with the Project.
16. Sedimentation	Not to be implemented	Quantitative measurement and evaluation are difficult.
17. Growth of weeds	Not to be implemented	Quantitative measurement and evaluation are difficult. Moreover, there is no mention to the growth of weeds by the Project in the EIA Report, and there is no clear relation between the Project and growth of weeds.

Following table shows the monitoring items in construction stage. "Odor" will not be caused by the Project, sill, the problem could be caused by bad habitat such as throwing away garbage to the canals. However, it is mentioned that "Odor" is to be monitored in construction stage and monitoring stage in M/D in 2014. MWRI has a duty to dredge canals biannually as a routine work, and it can be assessed by confirmation of dredging implementation.

Table 3-2.2 Environmental monitoring items for construction stage
(to be covered by the contractor under the supervision of MWRI)

Items (proposed in the EIA Report)	Decision of implementation	Reasons
1. Climate and weather	Not to be implemented	Any impacts by the construction works are expected. According to the Checklist in the EIA Report, it is evaluated as "D" for this item.
2. Air emission	To be implemented as planned	
3. Surface water quality	To be implemented as planned	
4. Groundwater quality	To be implemented as planned	
5. Groundwater level	To be implemented	It is not included in the monitoring items in the EIA Report, however, it is to be monitored since it is recommended by EEAA in 2010.
6. Noise	To be implemented as planned	
7. Vibration	To be implemented as planned	
8. Water flow and river morphology	To be implemented as planned. It is needed to keep same discharge to the downstream for farming.	
9. Land use and land tenure	Whether payment to the land owners for the stockyard has done shall be checked.	
10. Fishery	Instead of impact on the fishery, whether mud water is treated is monitored. Surface water quality check can substitute.	Since there is a possibility that waste water containing cement form the batcher plant can give damage to ecosystem in the river, the monitoring focuses on the waste water treatment. In case of complaints from the fishermen, it can be managed by employment of them as construction labors.
11. Income	Not to be implemented	Since negative impacts on incomes of neighboring people and beneficial farmers are not expected, monitoring of income is not

Items (proposed in the EIA Report)	Decision of implementation	Reasons
		necessary.
12. Access to the Project Site	Whether the schedule management of construction vehicles for decentralization is prepared can be regarded as an indicator of monitoring for access to the project site.	
13. Health and safety	To be implemented as planned	
14. Safety of regulators	Not to be implemented	Cofferdam is put by using pile sheets, and such construction works will not cause damage to the existing regulators. It is, thus, not necessary to monitor the safety.
15. Solid waste	To be implemented as planned	
16. Odor	It can be assessed by frequency of canal dredging. It is done as a routine work of MWRI since odor will not be generated by the Project.	
17. Sedimentation	Not to be implemented	Quantitative measurement and evaluation are difficult.
18. Growth of weeds	Not to be implemented	Quantitative measurement and evaluation are difficult. Moreover, there is no mention to the growth of weeds by the Project in the EIA Report, and there is no clear relation between the Project and growth of weeds.
19. Complaints	To be implemented	

Following table illustrates monitoring items in operation stage. “Odor” and “Solid waste” are not caused by the Project directly, instead, those problems could be caused by bad habitat such as throwing away garbage to the canals as well as in construction stage. MWRI will dredge canals biannually as a routine work instead of as one of project works, and it can be assessed by confirmation of dredging implementation. Some items, namely, water flow and river morphology, surface water quality, noise, vibration are not included in the EMP. However, they are to be monitored in terms of Environmental Auditing.

Table 3-2.3 Environmental monitoring items for operation stage

(to be covered by MWRI)

Items (proposed in the EIA Report)	Decision of implementation	Reasons
1. Surface water quality	To be implemented	
2. Groundwater quality	To be implemented	
3. Groundwater level	To be implemented	
4. Noise	To be implemented	
5. Vibration	To be implemented	
6. Water flow and river morphology	To be implemented	
7. Fishery	Not to be implemented	Effluent water that can damage to fishery will not be generated after the completion of construction works, and impacts on the fishery is not expected.

Items (proposed in the EIA Report)	Decision of implementation	Reasons
8. Safety of the regulators	Not to be implemented	No concern about safety of the regulators is expected.
9. Solid waste	It is not implemented, since it is a routine works of MWRI, and out of scope of the Project.	Solid waste will not be generated after the completion of construction works, and it is difficult to evaluate quantitatively. Neighboring people sometimes throw away garbage to the canals, such waste is dredged as a routine work of MWRI.
10. Odor	It is not implemented within the Project. It can be done by frequency of canal dredging. However, it is a routine works of MWRI, and out of scope of the Project.	
11. Sedimentation	Not to be implemented	Quantitative measurement and evaluation are difficult.
12. Growth of weeds	Not to be implemented	Quantitative measurement and evaluation are difficult.
13. Complaints	Complaints will be handled, if any (as planned).	

Based on the proposed monitoring items, the actual monitoring activities shall be done. It is noted that implementation organizations of monitoring varies by stage. Monitoring cost in pre-construction stage is included in the fee of S/V consultant. On the other hand, that in construction stage is included in the construction cost, while it is covered by the general budget of MWRI in the operation stage. Any statements of dissatisfaction or complaints from the neighbor villagers are to be received by MWRI official personnel at the site. The documented reports related to the issues should be submitted RGBS in Cairo to be reviewed. Following table shows the recommended monitoring plan.

Table 3-2.4 Monitoring Plan (pre-construction stage)

Item	Parameter	Measurement Point	Done by	Responsible organization
1. Air emission	SO_2, NO_2, CO, SPM, CO_2	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	S/V Consultant	MWRI
2. Surface water quality	One set*	1) Upstream of current regulators (just upstream of Abo Gabal Canal) 2) Just downstream of the new Ibrahimia regulator 3) Just downstream of the new Buhl Yusef Cana	S/V Consultant	MWRI
3. Groundwater quality	One set*1	BH-N7 and BH- N10 (2 points) in Figure 3-2.1 for covering one set of water quality check (EC, pH and DO are to be monitored at all of 13 points.)	S/V Consultant	MWRI
4. Groundwater	Water level	All 13 points in Figure 3-2.1	S/V	MWRI

Item	Parameter	Measurement Point	Done by	Responsible organization
level			Consultant	
5. Noise	Noise	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	S/V Consultant	MWRI
6. Vibration	Vibration	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	S/V Consultant	MWRI
7. Land use and land tenure	Securement of land for the temporary yard (confirmation of agreement with land owner) and confirmation of mosque transfer	–	MWRI*2	MWRI
8. Fishery	Number of fishermen and their legalities	The targets are those who catch fish from 300m upstream of DGRs to 500 m downstream of NDGRs (around 1,000m distance).	S/V Consultant	MWRI

*1: Water quality check parameters: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

*2: It is tentatively set as MWRI, however, it is to be discussed at the biding.

Table 3-2.5 Monitoring Plan (construction stage)

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
1. Air emission	SO_2, NO_2, CO, SPM, CO_2	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Monthly	Contractor	MWRI
2. Surface water quality	One set*1	1) Upstream of current regulators (just upstream of Abo Gabal Canal) 2) Just downstream of the new Ibrahimia regulator 3) Just downstream of the new Buhl Yusef Cana	Once per 2 months	Contractor	MWRI
3. Groundwater quality	One set*1	BH-N7 and BH- N10（2 points）in Figure 3-2.1 for covering one set of water quality check (EC, pH and DO are to be monitored at all of 13 points.)	Once per 2 months	Contractor	MWRI
4. Groundwater level	Water level	All 13 points illustrated in Figure 3-2.1	Monthly	Contractor	MWRI

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
5. Noise	Noise	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Monthly	Contractor	MWRI
6. Vibration	Vibration	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Monthly	Contractor	MWRI
7. Land use and land tenure		Confirmation of payment to the landowners	-	MWRI*2	MWRI
8. Water flow and river morphology	Water discharge	Regular water level measurement point of Ibrahimia Canal and Bahr Yusef Canal beside Dirout Office of Water Distribution Section	Every day	MWRI	MWRI
9. Fishery	Complaints from the fishermen	-	-	MWRI	MWRI
10. Access to the Project Site	Check of car arrangement schedule	-	Every day	Contractor	MWRI
11. Health and safety	- Health check - Assignment of traffic control - Proper car arrangement	-	Monthly Every day Every day	Contractor	MWRI
12. Waste	Frequency of waste management	Around the construction site	Weekly	Contractor	MWRI
13. Complaint	Frequency of complaint from the people	-	-	MWRI	MWRI

*1: Water quality check parameters: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO$_3$, HCO$_3$, Total Alkalinity, Ca, Mg, Na, K, Cl. NO$_3$, NO$_2$, PO$_4$, S, SO$_4$ Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

*2: It is tentatively set as MWRI, however, it is to be discussed at the biding.

Table 3-2.6 Monitoring Plan (operation stage)

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
1. Groundwater level	Water level	All 13 points illustrated in Figure 3-2.1	Twice per year	MWRI	MWRI
2. Surface water quality	One set*	1) Upstream of current regulators (just upstream of Abo Gabal Canal)	Twice per year	MWRI	MWRI

Item	Parameter	Measurement Point	Frequency	Done by	Responsible organization
		2) Just downstream of the new Ibrahimia regulator Just downstream of the new Buhl Yusef Canal			
3. Groundwater quality	One set*	BH-N7 and BH- N10（2 points）in Figure 3-2.1 for covering one set of water quality check (EC, pH and DO are to be monitored at all of 13 points.)	Twice per year	MWRI	MWRI
4. Noise	Noise	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Twice per year	MWRI	MWRI
5. Vibration	Vibration	1) In front of the illegal café 2) Railroad crossing 3) In front of the school which located on opposite of Mosque No.1（Port Side Street） 4) In front of the Dirout Water Distribution office	Twice per year	MWRI	MWRI
6. Water flow and river morphology	Water discharge	Regular water level measurement point of Ibrahimia Canal and Bahr Yusef Canal beside Dirout Water Distribution Office	Twice per year	MWRI	MWRI
7. Complaint	Frequency of complaint from the people	-	-	MWRI	MWRI

Based on the M/D on 21st May 2014, the monitoring period is set at one year since the operation is started.

* One set of water quality check parameter: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO$_3$, HCO$_3$, Total Alkalinity, Ca, Mg, Na, K, Cl. NO$_3$, NO2, PO$_4$, S, SO$_4$ Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

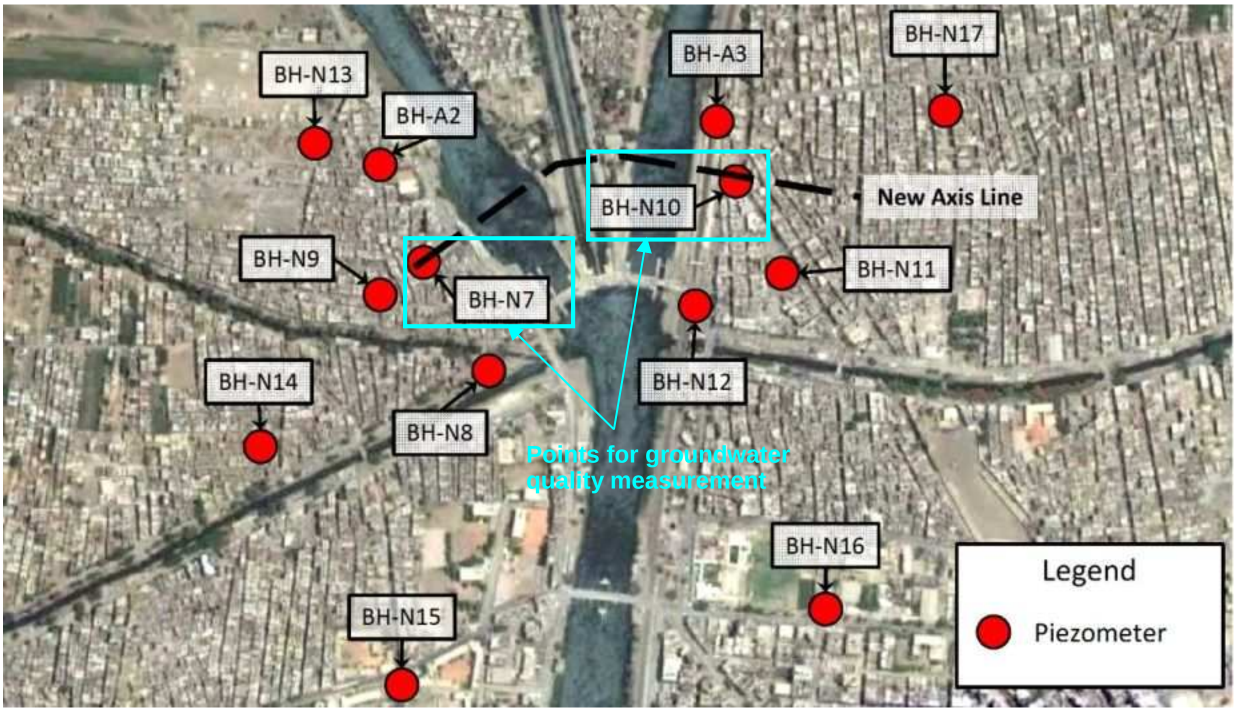

Figure 3-2.1 Location of the 13 piezometers for groundwater

Based on the monitoring plan mentioned above, actual monitoring is to be done. It is recommended to use the monitoring form as shown below:

(1) Pre-construction stage

1) Response and actions by the government

Monitoring Item	Monitoring Results in Report Period
Number and contents of responses from the people Actions taken by the government based on the complaints from the people	

2) Pollution

- Air Pollution

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred International Finance Cooperation (IFC) Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
SO_2	[µg/m^3] hr 24 hr			<350µg/m^3 <150µg/m^3	- <20µg/m^3	Once per month
NO_2	[µg/m^3] 1 hour 24 hours			<400µg/m^3 <150µg/m^3	<200µg/m^3 -	Once per month
CO	[mg/m^3] 1 hour 8 hours			<30mg/m^3 <10mg/m^3	20ppm/hr (Japanese standard) -	Once per month
SPM	[µg/m^3] 24hr			<150µg/m^3	<0.1mg/m^3(Japanese standard)	Once per month

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
Noise/ Vibration	dB			<65 (downtown in daytime) <55 (downtown in night)	<55 (daytime) <45 (night)	Once per month

*It is needed to pay consideration to minimize noise for the illegal café.

- Water pollution (surface water and groundwater)

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
One set of water quality parameters*						Once per 2 months

*Parameters of water quality check: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

Table 1-3.3 and Table 1.3.4 are to be referred as the standards for those water quality parameters.

3) Natural environment

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Groundwater level	- Depth of groundwater level		

4) Social environment

Environmental parameter	Monitoring results	Measures taken
Number of complaint about land lease/completion of land lease contract and payment		

Environmental parameter	Monitoring results	Measures taken
Relocation of the mosques Number of fishermen and their legalities		

(2) Construction stage

1) Response and actions by the government

Monitoring Item	Monitoring Results in Report Period
Number and contents of responses from the people Actions taken by the government based on the complaints from the people	

2) Pollution

- Air Pollution

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred International Finance Cooperation (IFC) Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
SO_2	[μg/m^3] hr 24 hr			<350μg/m^3 <150μg/m^3	- <20μg/m^3	Once per month
NO_2	[μg/m^3] 1 hour 24 hours			<400μg/m^3 <150μg/m^3	<200μg/m^3 -	Once per month
CO	[mg/m^3] 1 hour 8 hours			<30mg/m^3 <10mg/m^3	20ppm/hr (Japanese standard) -	Once per month
SPM	[μg/m^3] 24hr			<150μg/m^3	<0.1mg/m^3(Japanese standard)	Once per month

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
Noise/ Vibration	dB			<65 (downtown in daytime) <55 (downtown in night)	<55 (daytime) <45 (night)	Once per month

*It is needed to pay consideration to minimize noise for the illegal café.

- Water pollution (surface water and groundwater)

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
One set of water quality parameters*						Once per 2 months

*Parameters of water quality check: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn
Table 1-3.3 and Table 1.3.4 are to be referred as the standards for those water quality parameters.

3) Natural environment

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Groundwater level	- Depth of groundwater level		
Solid wastes	- Removal and disposal of waste		
Water flow and morphology	- Measurement of water level of the canals and estimation of discharge		
Odor*	- Confirmation of frequency of dredging by MWRI		
Impact on ecosystem, if any	- Complaints about damage to ecosystem in the construction site		

*Based on the M/D in 2014, odor can be checked by means of confirmation of implementation of dredging.

4) Social environment

Environmental parameter	Monitoring results	Measures taken
Number of complaint about land lease and payment		
Number of complaint about traffic jam		
Number of complaint about noise/vibration		
Number of complaint about impact on fishery		

5) Working environment (Include working safety)/ Accident

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Safety check for carrying the heavy machineries into the work area.			First time of the construction work
Safety check for refueling car accessing the work sites.			Everyday
Safety check for carrying-out of the heavy machineries from the work sites.			Last time of the construction work.
Assignment of traffic control staff			Everyday
Checking of the heavy machineries if keeping correct routes and speed.			Everyday
Installation of project sign board around the field.			First time of the construction work

6) Hazards (Risk) of Infectious diseases such as HIV/AIDS

Environmental parameter	Monitoring results	Measures taken	Monitoring date
Pay attention to the workers' health condition.			Every day
Arrange with the Local Unit office /Ministry of Health to carry out awareness creation on HIV/AIDS among the workers.			Once half a year

(3) Operation stage

1) Response and actions by the government

Monitoring Item	Monitoring Results in Report Period
Number and contents of responses from the people (including impacts on fishery) Actions taken by the government based on the complaints from the people	

2) Pollution

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
Noise/ Vibration	dB			<65 (downtown in daytime) <55 (downtown in night)	<55 (daytime) <45 (night)	Twice per year

*It is needed to pay consideration to minimize noise for the illegal café.

- Water pollution (surface water and groundwater)

Item	Unit	Measured Value (Mean)	Measured Value (Max)	Country's Standards	Referred IFC Guidelines	Remarks (Measurement Point, Frequency, Method, etc.)
One set of water quality parameters*						Twice per year

*Parameters of water quality check: pH, TDS, COD, BOD, DO, TSS, Turbidity, EC, CO_3, HCO_3, Total Alkalinity, Ca, Mg, Na, K, Cl. NO_3, NO_2, PO_4, S, SO_4 Temperature, Cr, Fe, Cu, Mn, Ni, Pb, Zn

Table 1-3.3 and Table 1.3.4 are to be referred as the standards for those water quality parameters.

3) Natural environment

Environmental parameter	Monitoring Item	Monitoring Results and Dates
Groundwater level	- Depth of groundwater level	
Water flow and morphology	- Measurement of water level of the canals and estimation of discharge	
Odor and Waste*1	- Confirmation of frequency of dredging by MWRI	
Impact on ecosystem, if any*2	- Complaints about damage to ecosystem in the construction site	

*1: Based on the M/D in 2014, odor and waste can be monitored through confirmation of implementation of dredging.

*2: Particular ecosystem in the construction site is not identified, therefore, just in case of any complaints from the residents.

3-3 Establishment of Security Management Committee (SMC)

For the duration of the Project, it is proposed to establish the Security Management Committee, which coordinates, assesses, approves various issues to maintain security of the project. The Committee meeting will be held monthly to share the monitoring results, and if some problems such as violation of the Egyptian environmental standard are identified, measures to be taken should be discussed at the meeting. Furthermore, the ad hoc SMC meetings will be organized according to necessity. Moreover, the committee will handle any complaints of the people during the Project period. Proposed constitute and roles of the committee are as follows:

1 Committee consists of RGBS staff of Dirout and Cairo, S/V consultant and Contractor.

2 Roles of the committee are as shown below:

  (1) Supervision of monitoring and examination of monitoring result,

  (2) Taking measures if some problems are identified during the monitoring activities, for instance, a result varies from the standard

  (3) Handling of complaints from the people

  (4) Identification and counting of those who catch fish around the DGRs regardless of with or without of license, and taking measurement as required

  (5) Reporting, recording and information sharing, especially, any issues identified and measured taken

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Volume VI - MATHEMATICAL MODEL ANALYSIS

1. Water Surface Profile Analysis on NDGRs

1-1 Objective and method of analysis

(1) Analysis objective

The objective of the water surface profile analysis of the new regulator is to calculate the water surface profile impacted by the NDGRs associated with the inflow from the Assiut regulator intake. The analysis is conducted by one-dimensional unsteady flow analysis using the Ibrahimia canal cross-section, roughness coefficient, and boundary conditions given in measurement results, to identify whether or not there are locations at risk of overtopping the existing bank.

Two water surface profile analyses were carried out: (1) non-uniform flow analysis to determine the range of impact during the maximum design discharge, (2) unsteady flow analysis to determine the extent and range of impact of the water surface profile over time when a gate is closed under the maximum design discharge.

(2) Target of the analysis

The analysis targets is the 60km section of the Ibrahimia canal that stretches from the Assiut regulator intake to the NDGRs. The slope of the riverbed of the canal in this section is slight, about 1/25,000, the river width is about 60m, the water depth is about 6m, and the planned flow capacity of the canal at maximum discharge is 474m^3/s.

The upstream control water level of the existing DGRs will increase from the current maximum WL 46.1m to WL 46.3m with the construction of the new regulator. Therefore, the DGRs was taken as a starting point for the water surface profile analysis to check whether or not there was an effect on the water surface profile at the planned maximum discharge of 474m^3/s.

Unsteady flow analysis was also carried out under the planned design discharge of 474m^3/s after the construction of the new regulator, to determine the effect on the water surface profile when one gate is suddenly closed for any reason.

(3) Analysis method

a) Non-uniform flow analysis

1) Basic equations of non-uniform flow analysis

i) Basic equations

In open channel flow, flow varies depending on location; In non-uniform flow, the flow depth and flow velocity vary with time. Water surface in non-uniform flow is tracked using two basic equations of non-uniform flow: (1) stepwise calculations, or (2) the graphical method.

In both cases, calculations are carried out from a known starting point; towards the upstream side in the case of steady flow, and towards the downstream side in the case of rapid flow.

With the stepwise calculations, the water depths at successive points are deduced from a known point, and the calculations proceed verifying the energy by applying Bernoulli's theory. This method has many merits, (1) calculations can be carried out at any cross-section regardless of steadiness or rapidity of flow, (2) losses apart from those caused by friction can be calculated. By dividing the water channel into ideal calculation sections and applying boundary conditions at the nodes, the calculation gives the successive shapes of the water surface so that Bernoulli's equation is satisfied in each section. Applying Bernoulli's equation to cross-sections I and II in Figure 1-1.1 yields the following equations.

$$\mathrm{h}_1+\frac{\alpha\cdot\mathrm{Q}^2}{2\mathrm{g}\cdot{\mathrm{A}_1}^2}+z_1+h_f+\Delta h_p=\mathrm{h}_2+\frac{\alpha\cdot\mathrm{Q}^2}{2\mathrm{g}\cdot{\mathrm{A}_2}^2}+z_2$$

$$h_f=\frac{\boldsymbol{Q^2\cdot l}}{\boldsymbol{2}}\left(\frac{\boldsymbol{{n_1}^2}}{\boldsymbol{R_1^{\frac{4}{3}}{A_1}^2}}+\frac{\boldsymbol{{n_2}^2}}{\boldsymbol{R_2^{\frac{4}{3}}{A_2}^2}}\right)$$

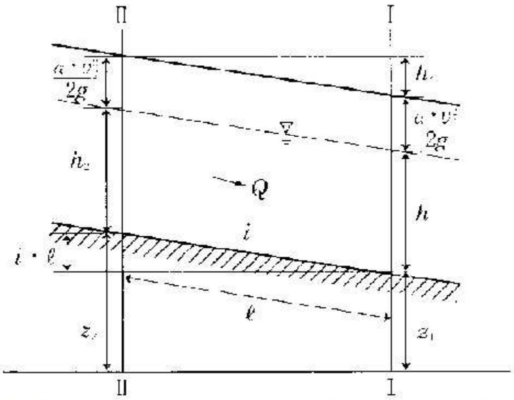


Figure 1-1.1 Explanation of non-uniform flow calculation

Source: "Canal Works." Land Improvement Project Program Design Standard. *Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries* (2008).

Where,

z: Height from bedrock to bottom of water channel (m)

h: Water depth (m)

Q: Discharge (m^3/s)

v: Flow velocity (Q/A) (m/s)

i: Slope of the water channel bottom

h_f: Water head loss produced at cross-sections I, II (m)

Δh_p: Amount of change in water level due to bridge piers (m)

ℓ: Slope length between cross-sections I to II (m)

R: Hydraulic radius (m)

A: Area of cross-section of water (m^2)

n: Roughness coefficient

g: Gravitational acceleration 9.8 (m/s^2)

α: Energy correction function

Subscripts 1, 2: Indicate values at cross-sections 1 and 2 respectively.

When the energy at cross-section I is given, the water depth is calculated at cross-section II so that adding the hydraulic head loss between cross-sections I and II to the height of this energy line gives the height at cross-section II.

The following shows an example of non-uniform flow calculation arrived at by stepwise calculation.

Table 1-1.1 Example of water surface tracing calculation in case of non-uniform flow in water channel

Section name	Section XX	Starting point water depth	1.50m	Bottom width of trapezoidal cross-section water channel	2.0m
Detailed position	No. 18 to No. 20	Flow rate	6.00m^3/s	Side slope	1-1
Starting point	(No. 20) bottom elevation 47.500m	n	0.013		

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12) Head loss			(13)	(14)	(15)	(16)
Measurement point	Section length (m)	Water depth h (m)	Water cross-sectional area A (m^2)	Flow velocity V (m/s)	Velocity head $V^{2-2}g$ (m)	Wetted perimeter P (m)	Hydraulic radius R (m)	$R^{4/3}$	Friction slope S_f	Friction slope S_f	Friction head loss (m)	Other head losses	Total (m)	Bottom elevation (m)	Height of total energy line (m)	Height of total energy line (m)	Error
No.20		1.500	5.250	1-143	0.067	6.242	0.841	0.794	0.00028					47.500	49.067		
										0.00032							
No.19	50.000	1.400	4.760	1.261	0.081	5.959	0.799	0.741	0.00036		0.016	0	0.016	47.550	49.031	49.083	- 0.052
										0.00029							
		1.490	5.200	1-154	0.068	61-14	0.837	0.789	0.00029		0.015	0	0.015	47.550	49.108	49.082	0.026
										0.00029							
		1.465	5.076	1-182	0.071	6.143	0.826	0.775	0.00030		0.015	0	0.015	47.550	49.086	49.082	0.004 ok
										0.00032							
No.18	50.000	1.440	4.954	1.211	0.075	6.072	0.816	0.763	0.00033		0.016	0	0.016	47.600	491-15	49.102	0.013
										0.00032							
		1.420	4.856	1.236	0.078	6.016	0.807	0.751	0.00034		0.016	0	0.016	47.600	49.098	49.102	- 0.004 ok

Notes) 1st line (1) to (9), (13): Enter the quantities for the given conditions at the starting point (10): Friction slope: $S_f = Q^2 \cdot n^2 / A^2 \cdot R^{4/3} = (V^{2-2}g) \times 2gn^2 / R^{4/3}$. When n is determined, (6) may be multiplied by the constant $2gn^2$ and divided by (9).
(14): (3) + (6) + (13)

2nd line (3): Enter assumed water depth. (4) to (10), (13), (14): Enter the various quantities for (3), (11): Average value of (10) on the 1st line and (10) on the 2nd line, (12): (11) × (2), (15): (14) on the 1st line + (12) on the 2nd line,
(16): Difference of (15) and (14) on each line, revise the assumed water depth until the error is within the allowable range (±0.01 or less), and repeat the calculation.

Source: "Canal Works." Land Improvement Project Program Design Standard. *Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries* (2008).

ii) Friction loss

Manning's equation is used to calculate hydraulic head loss due to friction. Friction head loss in a section of length ℓ is obtained using the following equation.

$$h_f = \frac{Q^2 \cdot \ell}{2}\left(\frac{n_1^2}{R_1^{4/3} \cdot A_1^2} + \frac{n_2^2}{R_2^{4/3} \cdot A_2^2}\right) = \frac{1}{2}\left(\frac{n_1^2 \cdot V_1^2}{R_1^{4/3}} + \frac{n_2^2 \cdot V_2^2}{R_2^{4/3}}\right) \cdot \ell$$

Where,

Q : Discharge (m^3/s)
A : Water cross-sectional area (m^2)
h_f : Friction head loss (m)
ℓ : Distance between the sections (m)
R : Hydraulic radius (m)
n : Roughness coefficient
V : Average flow velocity (m/s)
(Subscripts indicate the starting point and the finishing point of the relevant section)

iii) Amount of change in water level at bridge

The amount of change in the water level due to bridge piers is obtained from the D'Aubuisson equation as follows.

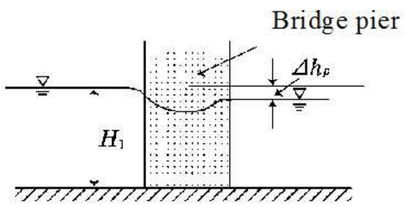


Figure 1-1.2 Amount of drawdown in water level due to bridge piers

$$\Delta h_p = \frac{Q^2}{2g}\left(\frac{1}{C^2 \cdot b_2{}^2 \cdot (H_1 - \Delta h_p)^2} - \frac{1}{b_1{}^2 \cdot H_1{}^2}\right)$$

Where,

Δh_p: Amount of change in water level due to bridge piers (m)

Q : Discharge (m^3/s)

C : Coefficient depending on the plane shape of the bridge pier (Figure 1-1.3)

b_1 : Water channel width immediately in front of the bridge pier (m)

b_2 : Net width after deducting the total width of the bridge piers from the water channel width

$\left(b_2 = b_1 - \sum t\right)$ (m)

t: Width of one bridge pier (m)

H_1: Water depth on upstream side of bridge pier (m)

g : Gravitational acceleration 9.8 (m/s^2)

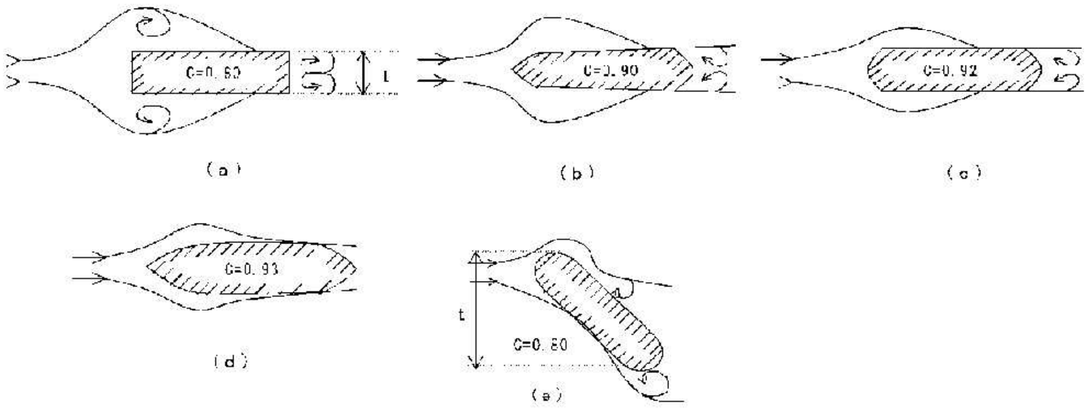


Figure 1-1.3 Coefficient for each shape of bridge pier

In the calculation, an approximate value $\Delta h_p'$ of Δh_p is obtained from the following equation, and based on the approximate value $\Delta h_p'$, a trial calculation is repeatedly carried out until the left side Δh_p of the above equation is equal to the right side Δh_p.

$$\Delta h_p' = \frac{Q^2}{2g \cdot b_1^2 \cdot H_1^2}\left[\frac{1}{C^2}\left(\frac{b_1}{b_2}\right)^2 - 1\right]$$

2) Analysis conditions

i) Water channel cross-section

The water channel cross-sections used in the water surface profile analysis were those obtained from the results of a separate survey carried out at a 50m pitch in the section 1,500m upstream of the existing DGRs, and at a 500m pitch from the 1,500m point upstream of the Ibrahimia Head regulator.

There are 168 sections including bridges, and the calculation section was about 60km in length. Figure 1-1.4 shows a longitudinal section of the water channel showing the elevation of the deepest riverbed.

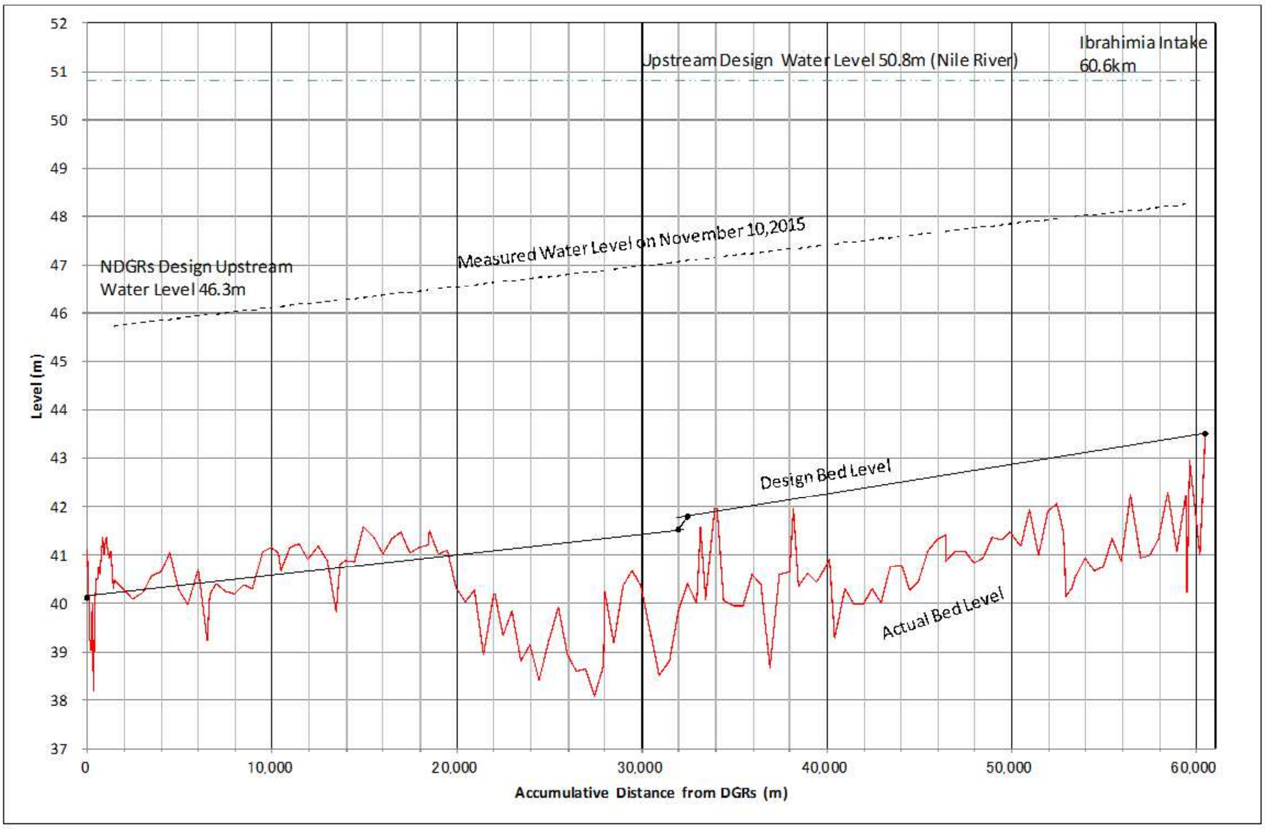


Figure 1-1.4 Longitudinal section of the Ibrahimia canal

In the section up to 20km upstream of the DGRs, the riverbed tends to be higher than the design bed level, but in the section from 20-60km upstream, the riverbed tends to be lower than the design bed level.

Because sedimentation moves 20km downstream this way, it is assumed that the canal loss of this section becomes quite big. Design canal bed level is shown in Figure 1-1.5.

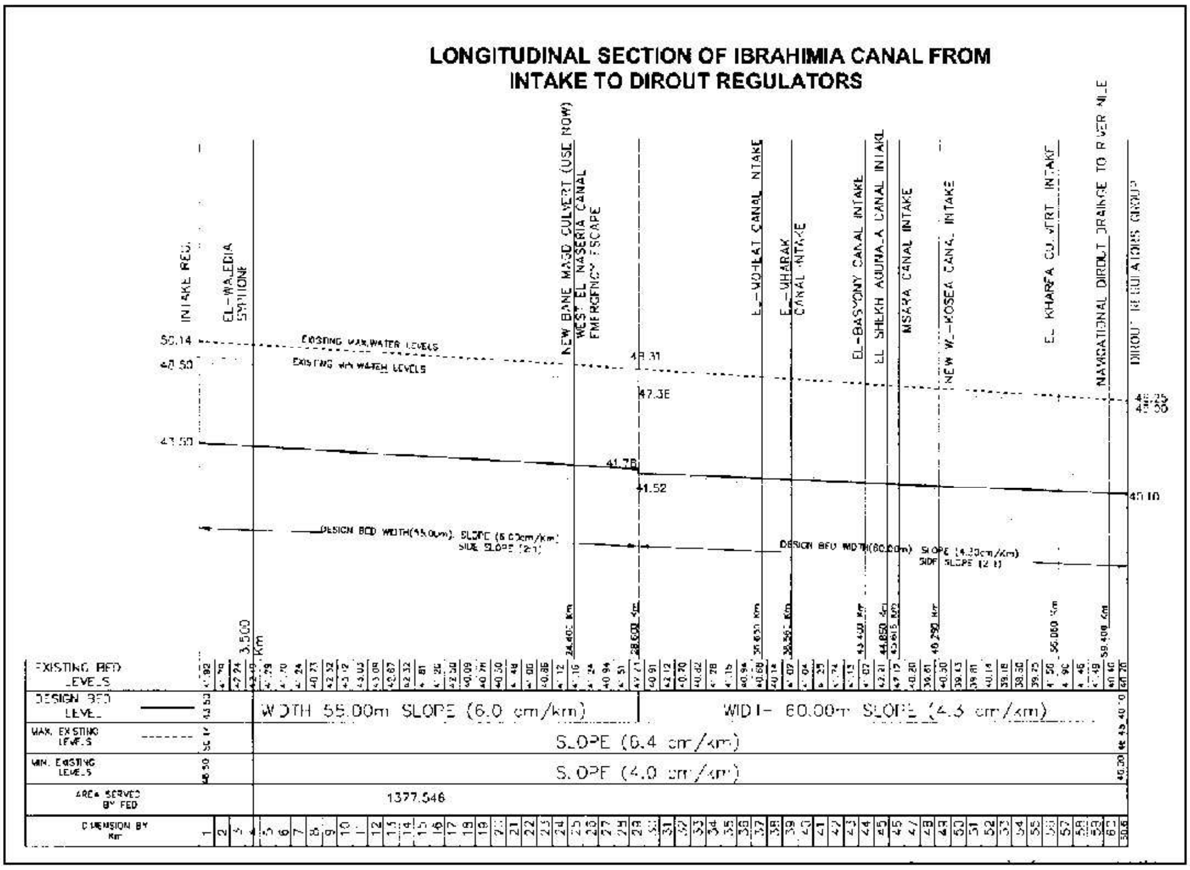

LONGITUDINAL SECTION OF IBRAHIMIA CANAL FROM INTAKE TO DIROUT REGULATORS
INTAKE REG.
EL-WALEDIA SYPHONE
NEW BANE MAGD CULVERT (USE NOW)
WEST EL NASERIA CANAL EMERGENCY ESCAPE
EL-MOHLAT CANAL INTAKE
EL-UHARAK CANAL INTAKE
EL-BASYONY CANAL INTAKE
EL SHEKH AGUNALA CANAL INTAKE
MSARA CANAL INTAKE
NEW W.-KOSEA CANAL INTAKE
EL KHARFA CULVERT INTAKE
NAVIGATIONAL DIROUT DRAINAGE TO RIVER NILE
DIROUT REGULATORS GROUP
50.14
46.50
43.50
EXISTING MAX.WATER LEVELS
EXISTING MIN WATER LEVELS
48.31
47.38
41.76
41.52
40.10
DESIGN BED WIDTH(55.00m) SLOPE (6.00cm/Km) SIDE SLOPE (2:1)
DESIGN BED WIDTH(60.00m) SLOPE (4.30cm/Km) SIDE SLOPE (2:1)
3.500 Km
24.405 Km
28.600 Km
36.650 Km
38.561 Km
43.400 Km
44.850 Km
45.615 Km
49.290 Km
56.060 Km
59.400 Km
EXISTING BED LEVELS
DESIGN BED LEVEL
MAX. EXISTING LEVELS
MIN. EXISTING LEVELS
AREA SERVED BY FED
DIMENSION BY Km
WIDTH 55.00m SLOPE (6.0 cm/km)
WIDTH 60.00m SLOPE (4.3 cm/km)
SLOPE (6.4 cm/km)
SLOPE (4.0 cm/km)
1377.546

Figure 1-1.5 Longitudinal profile of the Ibrahimia canal (design bed level)

ii) Bridges

There are bridges at 21 locations along the calculation section. The measurement results for the shapes, widths, number of bridge piers, and water channel cross-sections were used.

The main parameters are as shown in the following table.

Table 1-1.2 Existing bridge parameters

No	Type	Pier		Coordinates at center of bridg		Distance from Ibrahimia Head Regulator (m)
		Number	Width (m)	E (m)	N (m)	
B1	R.C.	12	0.70	319884	3009297	348
B2	Steel	2	7.23	319328	3009142	884
B3	R.C.	3	1.40	319251	3009130	1,057
B4	Steel	2[*1]	3.59	313431	3009132	7,264
		6	0.40			
B5	R.C.[*2]	18	0.40	313069	3009372	7,684
B6	R.C.	15	0.40	313038	3009397	7,729
B7	R.C. + Steel	14	0.40	308007	3013305	14,114
B8	R.C.	15	0.40	306267	3014926	16,500
B9	R.C. + Steel	14	0.35	303382	3017616	20,423
B10	R.C.	6[*1]	3.30	301997	3018920	22,330
		18	0.40			
B11	R.C. + Steel	16	0.35	298954	3021751	26,500
B12	R.C.	6[*1]	2.90	298287	3022385	27,409
		18	0.40			
B13	R.C.	14	0.70	295158	3026441	32,545
B14	R.C. + Steel	16	0.40	291529	3031177	38,500
B15	R.C.	14	0.60	289015	3033669	42,068
B16	Wood	10	0.15	285442	3036942	46,906
B17	R.C. + Steel	8[*1]	2.05	285383	3037054	47,030
		16	0.40			
B18	R.C.	7[*1]	3.03	284651	3040149	50,220
		21	0.40			
B19	R.C. + Steel	15	0.40	283712	3043769	53,945
B20	R.C.	15	0.70	283789	3048980	59,500
B21	R.C. + Steel	18	0.35	283904	3049825	60,322

Notes: 1) Upper section value of Pia colum is used when disherge volume is high.
2) R.C. : Reinforced Concrete

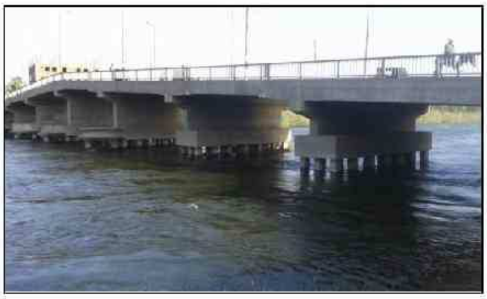


Figure 1-1.6 Upstream view of the existing bridge (No.B18)

iii) Water intake facilities

The positions and shapes of intake facilities along the calculation section were determined from the measurement results of the same survey. The planned maximum water intake amount was 19m^3/s for the total number of intake facilities in the section. This was determined by factors such as the scale of the intake facilities, and the area benefitting from each intake facility as provided by the Water Distribution Sector. The results are shown in the following table.

Table 1-1.3 Parameters of the water intake facilities

ID	Intake				Name of Canal	Distance from B.P (m)
	Width (m)	Depth (m)	Area (m^2)	Demand (m^3/s)		
L0	2.0	0.99	1.98	0.6		24094
L1	4.0	1.54	6.16	1.3	EL-Moheat	36547
L1-P1	D 0.9	0.90	0.64	0.2		36858
L2	5.0	1.93	9.65	2.7	EL-Maharak	38468
L2-P1	D 0.55	0.55	0.24	0.1		42116
L3	4.0	1.40	5.60	1.4	EL-Basuoni	42459
L4	D 3.0*2	1.40	6.79	1.5	EL-Shaekh Awnalla	44785
L4-1	D 0.75	0.75	0.44	0.1	Ganibia El sheakh Awmalla	44914
R1	5.0	1.32	6.60	2-2	Masara	45634
L5	6.0	2-23	13.38	5.9	EL-Kosia	48086
L7	D 1.0	1.00	0.79	0.1	Ganibia Morad	50533
L8	D 1.05	1.05	0.87	0.1	El Daer	52328
L9	2-8	1.77	4.43	0.4	Sanabo & Nazlet Zaher	53257
R3	1-1	0.63	1.32	0.4	EL-Kharfa	55956
L10	D 1.05	1.05	0.87	0.2		56970
L11	2.0	1.00	2.00	0.6		57851
L12	2.0	1.85	3.70	1.2	Ganibia Karsh & Banob	59778
Total			65.44	19.0		

Note: 'D' means diameter of pipe canal. Date of observation is 10 Nov. 2015.

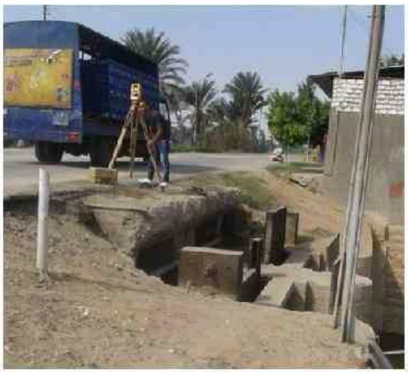


Figure 1-1.7 Photograph of water intake facility

iv) Flow rates

At the upstream of the Ibrahimia canal, the water levels and intake amounts were measured every day at a point upstream of the Ibrahimia Head regulator (Ibrahimia inflow, Nile River water level), and downstream of the regulator. At the downstream DGRs, the upstream and downstream water levels were measured daily, as was the discharge from the downstream of the Bahr Yusef regulator, and the downstream of the Ibrahimia regulator.

The design maximum intake amount was determined as follows.

Table 1-1.4 Design discharge at each regulator

Regulator		Design Discharge		Remark	
		Discharge (m3/s)	ratio (%)		
DGRs	Ibrahimia	186	39	455	96
	Bahr-Yusef	227	48		
	Sahelyia	5	1		
	Diroutiah	12	3		
	Badraman	9	2		
	Abo Gabal	7	1		
	Irad Delgaw	9	2		
Direct Intake		19	4	19	4
Total		474	100	474	100

v) Roughness coefficient

The roughness coefficient of the Ibrahimia Canal used in the water surface profile analysis was estimated from the results of flow rate measurements carried out at 12 cross-sections. It was also estimated by carrying out water surface profile analyses using verified values of actual measured water levels. The roughness coefficient used in this analysis was estimated by these two methods.

v-1) Estimation from measured flow velocity

The roughness coefficient of the Ibrahimia Canal was estimated using the two point method; by measuring the flow velocity at two cross-sections at the two ends of a 500m straight section on a 10km section with no water intake facilities and no obstructions. This was done within the 60km water channel section used as part of the Ibrahimia canal survey.

The measured flow velocities, flow rates, and estimated roughness coefficients are shown in Table 1-1.5.

Table 1-1.5 Results of estimated roughness coefficients from measured flow velocity

Section No.	Discharge Q (m^3/s)	$Q_{average}$ (m^3/s)	Cross section area A (m^2)	Velocity V(m/s)	P (m)	Hydraulic radius R (m)	Hydraulic gradient I (cm/km)	$I_{average}$ (cm/km)	$R^{2/3}$	$I^{1/2}$	Roughness coefficient n
Vel 1-1	296.5	295.7	389.1	0.760	77.17	5.04	6.93	5.07	2.940	0.0083	0.0322
Vel 1-2	295.0		414.8	0.713	75.90	5.47			3.103	0.0083	0.0362
Vel 2-1	293.1	291.1	422.8	0.689	84.39	5.01	5.14		2.928	0.0072	0.0305
Vel 2-2	289.1		435.8	0.668	84.00	5.19			2.997	0.0072	0.0322
Vel 3-1	290.2	289.5	376.7	0.769	72.41	5.20	6.32		3.003	0.0079	0.0310
Vel 3-2	288.8		386.8	0.749	74.22	5.21			3.006	0.0079	0.0319
Vel 4-1	284.5	285.7	443.8	0.644	83.28	5.33	3.21		3.051	0.0057	0.0269
Vel 4-2	286.9		408.1	0.700	78.62	5.19			2.998	0.0057	0.0243
Vel 5-1	287.6	287.3	390.1	0.737	93.32	4.18	4.68		2.595	0.0068	0.0241
Vel 5-2	287.0		424.8	0.676	103.94	4.09			2.556	0.0068	0.0259
Vel 6-1	278.9	278.1	408.2	0.681	97.06	4.21	4.12		2.606	0.0064	0.0245
Vel 6-2	277.3		422.3	0.658	100.55	4.20			2.603	0.0064	0.0254
										Average	0.0288

Roughness coefficient is calculated by the Manning formula as follows.

$V = (1/n)R^{2/3}I^{1/2}$ --> $n=(1/V)\ R^{2/3}I^{1/2}$

Where,

V: Velocity (m/s)
I: Canal bed gradient
R: Hydraulic mean depth (m) (=Hydraulic radius)
n: Roughness coefficient

Flow velocity produced a roughness coefficient 0.0288.

v-2) Estimates from actual measured water levels and discharges

Water surface profile analysis was carried out using previous Ibrahimia canal intake water levels and discharges, as well as the DGRs upstream water levels and discharges. To estimate the roughness coefficient, upstream and downstream water levels and discharge values under steady conditions (without fluctuation over two days) were used.

For the discharge scale, three discharges close to the design maximum intake were extracted, 400m^3/s, 300m^3/s, and 200m^3/s. These are shown in Table 1-1.6.

Total quantity of intake of the canal branch was calculated based on the distribution ratio of the design discharge calculated in Table 1-1.4.

The results of the intake distributions are shown in Tables 1-1.7 and 1-1.8.

Table 1-1.6 Selected results for observed discharge

Selected discharge (m^3/s)	Selected Date	Ibrahimia Head Regulator		DGRs			
		Observed discharge (m^3/s)	Observed DS WL (m)	Observed US WL (m)	Bahr-Yusef Discharge (m^3/s)	Ibrahimia Discharge (m^3/s)	Total Discharge (m^3/s)
400	2014/May/11	422.5	49.57	45.89	196.8	152.2	349.0
300	2014/July/18	300.9	48.52	45.62	156.3	130.2	286.5
200	2012/Dec/21	190.4	47.56	45.50	97.2	83.3	180.5

Table 1-1.7 Allocation of measured discharges based on the design allocation

Regulator		Design Discharge		Observed Dischage					
		Discharge (m3/s)	ratio (%)	400m3/s (2014/5/11)		300m3/s (2014/8/18)		200m3/s (2012/12/21)	
DGRs	Ibrahimia	186	39	405.6	96%	288.9	96%	182.8	96%
	Bahr-Yusef	227	48						
	Sahelyia	5	1						
	Diroutiah	12	3						
	Badraman	9	2						
	Abo Gabal	7	1						
	Irad Delgaw	9	2						
Direct Intake		19	4	16.9	4%	12.0	4%	7.6	4%
Total		474	100	422.5	100%	300.9	100%	190.4	100%

Table 1-1.8 Allocation of intake amounts based on the design allocation

ID	Name of	Demand(m^3/s)			
		Design	400m^3/s	300m^3/s	200m^3/s
L0		0.6	0.5	0.4	0.2
L1	EL-Moheat	1.3	1.1	0.8	0.5
L1-P1		0.2	0.2	0.1	0.1
L2	EL-Maharak	2.7	2.4	1.7	1.1
L2-P1		0.1	0.1	0.1	0.0
L3	EL-Basuoni	1.4	1.2	0.9	0.6
L4	EL-Sheakh Awnalla	1.5	1.3	0.9	0.6
L4-1	Ganibia El sheakh Awmalla	0.1	0.1	0.1	0.0
R1	Masara	2.2	2.0	1.4	0.9
L5	EL-Kosia	5.9	5.2	3.7	2.4
L7	Ganibia Morad	0.1	0.1	0.1	0.0
L8	El Daer	0.1	0.1	0.1	0.0
L9	Sanabo & Nazlet Zaher	0.4	0.4	0.2	0.2
R3	EL-Kharfa	0.4	0.4	0.2	0.2
L10		0.2	0.2	0.1	0.1
L11		0.6	0.5	0.4	0.2
L12	Ganibia Karsh & Banob	1.2	1.1	0.8	0.5
Total		19.0	16.9	12.0	7.6

The following tables calculated roughness coefficient as a parameter so that calculated water levels were consistent with observed water level at the Ibrahimia Head regulator. The calculations used non-uniform flow analysis arrived at by a stepwise calculation method that considered the influence of the bridge and intake.

The non-uniform flow analysis that started from the upstream DGRs set actual survey water levels at the Ibrahimia Head regulator downstream as targeted water levels. The roughness coefficient at the time of calculation assumes this is a temporary set value. As for the calculations, the roughness coefficient is calculated until calculated water levels at the Ibrahimia Head regulator downstream, accord with the targeted water level.

The estimated roughness coefficients are shown in Table 1-1.9.

The result of the water surface profile analysis and the calculated roughness coefficient at every discharge is shown in Figures 1-1.8 to 1-1.10.

Table 1-1.9 Results of roughness coefficient estimation based on measured water levels and discharges

Selected discharge (m^3/s)	Selected Date	DGRs	Ibrahimia Head Regulator		Result of calculation			
		Observed US WL (m)	Observed discharge (m^3/s)	Observed DS WL (m)	Compare	Ibrahimia Head Regulator DS WL (m)	Judge	Result of roughness coefiicient
400	2014/May/11	45.89	422.5	49.57	<	49.63	NG	0.0260
					=	49.57	OK	0.0256
					>	49.49	NG	0.0250
300	2014/July/18	45.62	300.9	48.52	<	48.55	NG	0.0270
					=	48.52	OK	0.0267
					>	48.45	NG	0.0260
200	2012/Dec/21	45.50	190.4	47.56	<	47.60	NG	0.0305
					=	47.56	OK	0.0300
					>	47.52	NG	0.0295

The calculation results reveal the tendency of the roughness coefficient to decrease when water level and discharge increase in the Ibrahimia canal (Ven Te Chow. *Open-Channel Hydraulics*. NY: McGraw-Hill, 1959).

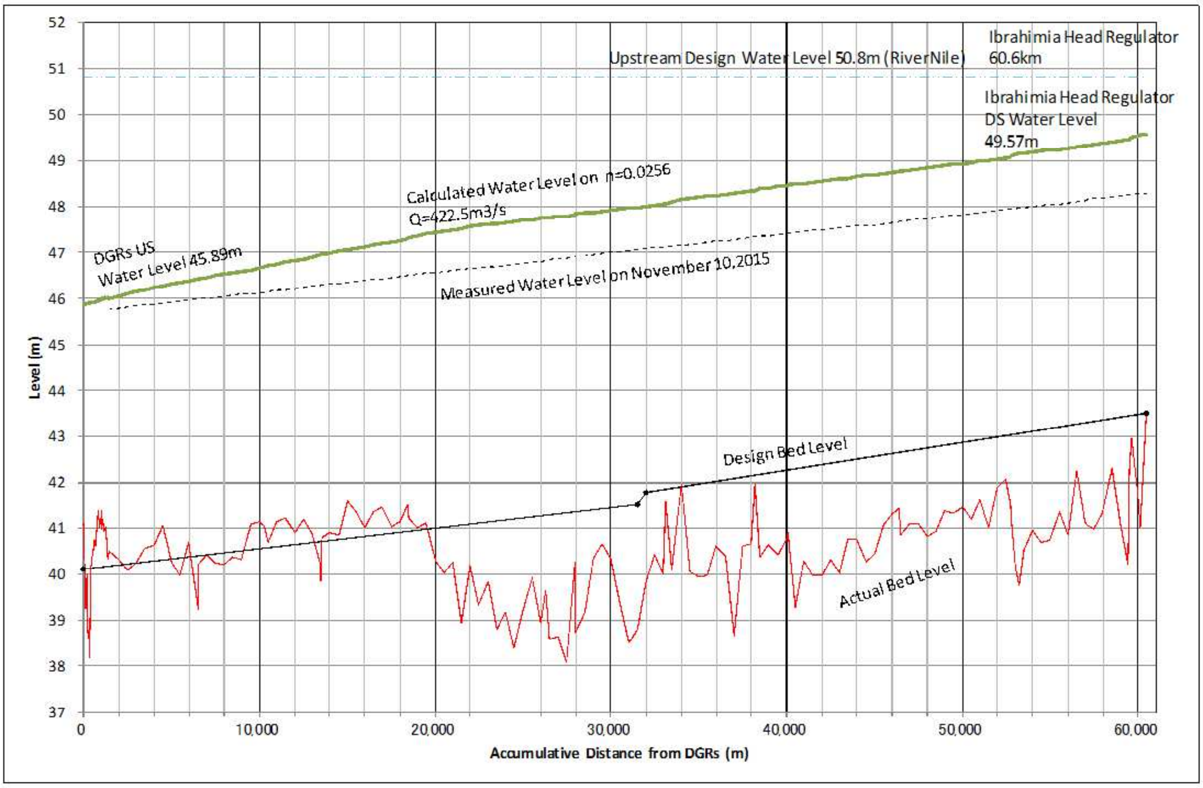


Figure 1-1.8 Result of roughness coefficient estimate from measured water levels and discharges (maximum discharge=422.5m^3/s, n=0.0256)

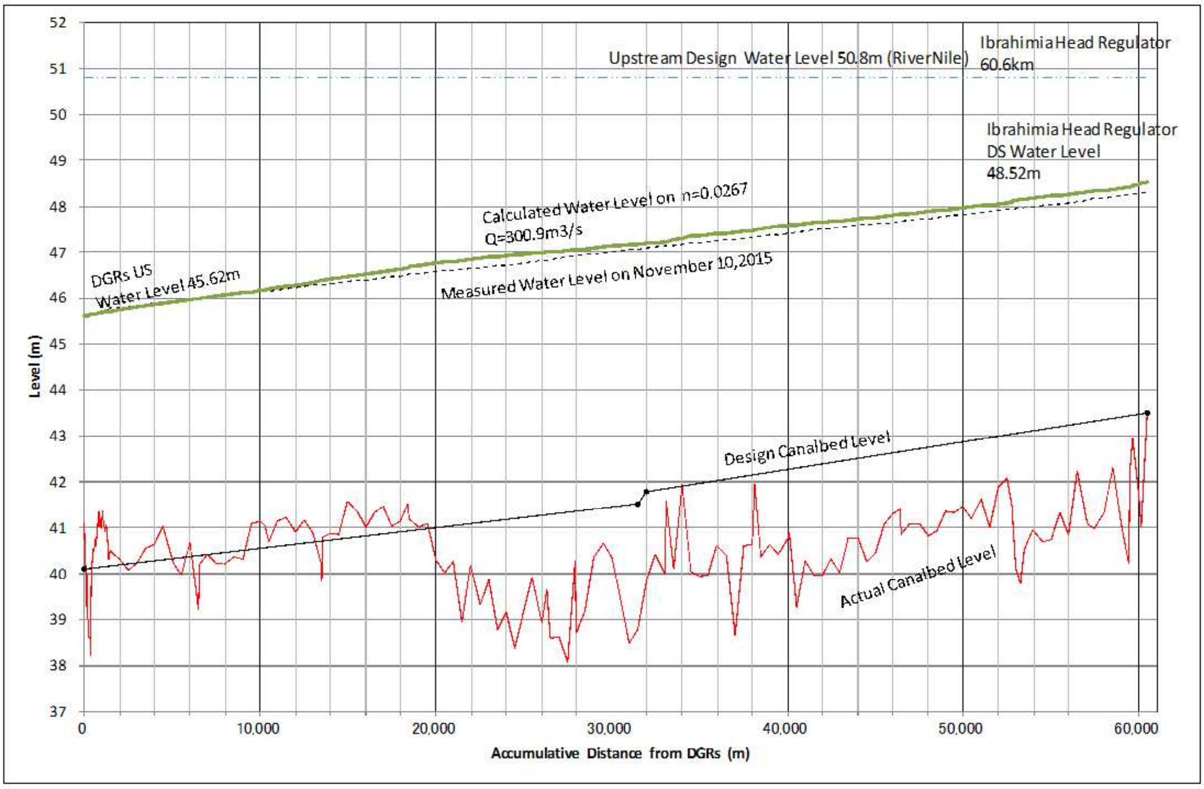


Figure 1-1.9 Result of roughness coefficient estimate from measured water levels and discharges (discharge=300.9m^3/s, n=0.0267)

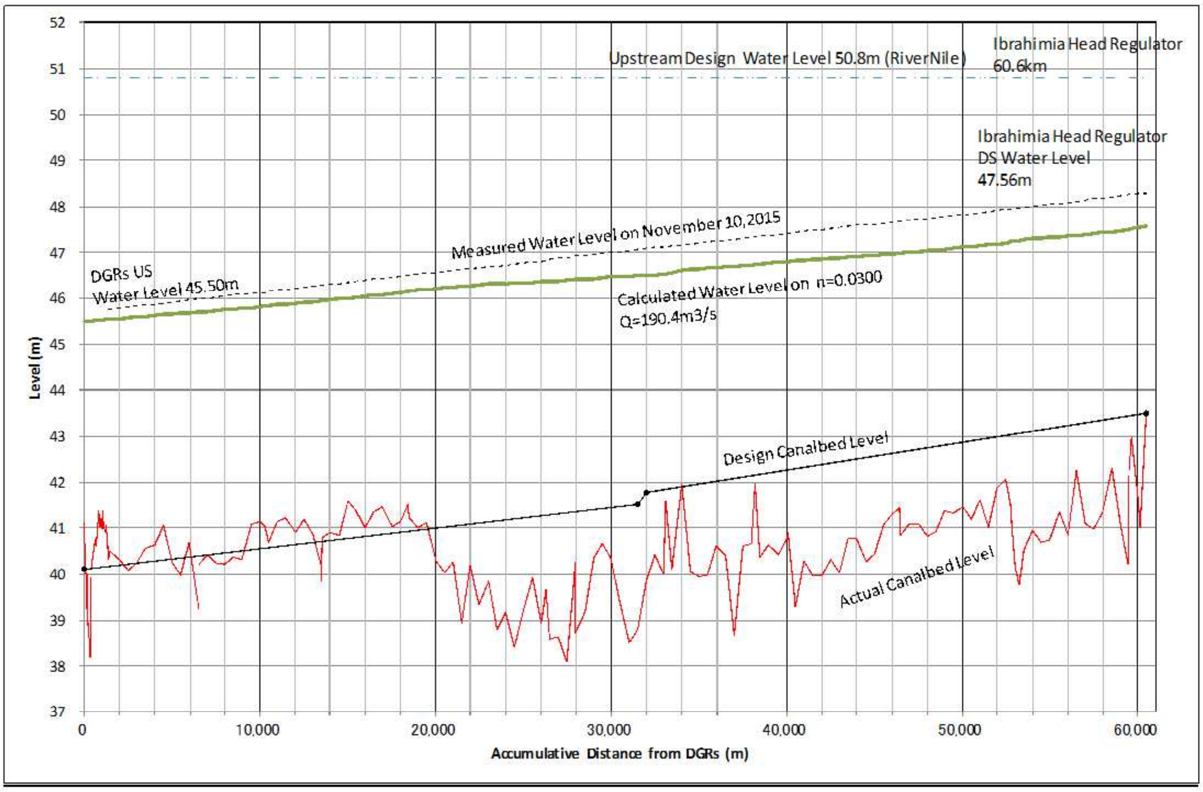


Figure 1-1.10 Result of roughness coefficient estimate from measured water levels and discharges (discharge=190.4m^3/s, n=0.0300)

v-3) Evaluation

According to version 4.0 of the *Hydraulic Reference Manual* published by the U.S. Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center, in March 2008, the roughness coefficient of an excavated dredged channel ranges from 0.025 to 0.030.

In addition, according to research conducted by the Water Research Center Egypt, the design roughness coefficient of Ibrahimia canal is 0.025, but the scattered garbage, raises the figure to 0.030 to 0.039.

A roughness coefficient of 0.0288 was provided at discharge of approximately 300m^3/s. This is only slightly greater than the roughness coefficient 0.0267 arrived at by inverse operations.

A roughness coefficient of 0.0256 resulted from calculations near the design discharge of 474m^3/s, and is considered a reasonable value for the analysis and can be applied to the design discharge.

The results of the roughness coefficient are as follows.

Table 1-1.10 Result of the roughness coefficient

Item	Discharge Q(m^3/s)	roughness coefficient n	Remarks
1.Measure Velocity	300	0.0288	May 2016
2.Estimation from actual measurement (inverse operation result)	400	0.0256	apply to design discharge
	300	0.0267	
	200	0.0300	
3.*Hydraulic Reference Manual*	-	0.025 – 0.030	Dredged Channel
4.Research paper by NWRC (Ibrahimia canal in Minya)	-	0.025	Design
	-	0.030 – 0.039	garbage

b) Unsteady flow analysis

1) Basic equations for unsteady flow calculation

Unsteady flow analysis was carried out to determine what would happen to the water surface profile if one gate suddenly closed for any reason, after the construction of the new regulator and under the design discharge 474m^3/s.

Unsteady flow is mathematically calculated by simultaneously solving the equations of motion and the equations of continuity. The equations of motion and equations of continuity for unidirectional flow such as river flow, etc, are expressed as follows with the downstream end (river mouth) as the origin.

$$\frac{1}{g}\cdot\left(\frac{\partial v}{\partial t}\right)+\frac{1}{g}\cdot\frac{\partial}{\partial x}\left(\frac{v^2}{2}\right)+I+\frac{\partial h}{\partial x}+\frac{n^2|v|v}{R^{\frac{4}{3}}}=0 \quad \cdots\cdots\cdots\cdots \quad (1)$$

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=q_x \quad \cdots\cdots\cdots\cdots \quad (2)$$

Where,

g: gravitational acceleration (m/s^2)
v: average flow velocity at the cross-section (m/s)
I: hydraulic gradient
h: water depth (m)
R: hydraulic radius (m)
n: Manning's roughness coefficient
A: water cross-sectional area (m^2)
Q: discharge (m^3/s)
q_x: lateral inflow rate per unit width per unit time (m^2/s)
x: distance (m)
t: time (s)

The most practical method of solving the partial differential equations described above (equations of motion and equations of continuity) for this type of mathematical calculation (for the scale and accuracy of the calculation) is the first order central difference method.

In this method of solution, grid points are set with water level points and flow velocity points separated in time by ⊿t/2 and in distance by ⊿x/2 as shown in Figure 1-1.11. Initial values are given as the values at j = 1, 2, and using these values the water level at j = 3 is obtained from the continuity equations, next using the values at j = 2, 3 the flow velocity is obtained at j = 4 from the equations of motion, and this method is repeated successively.

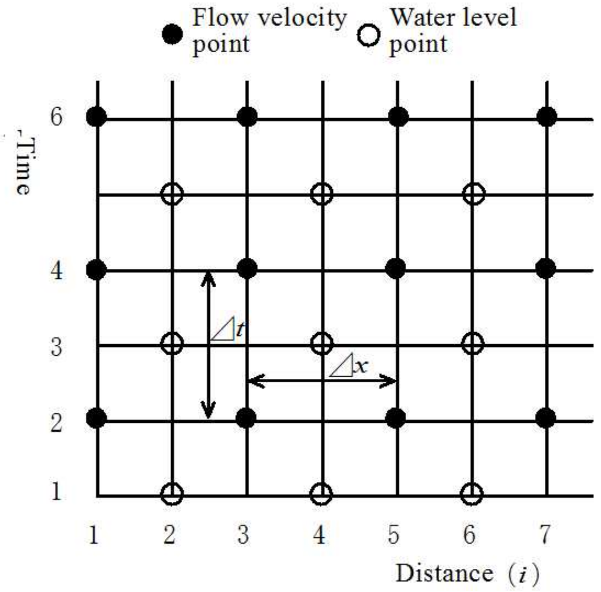


Figure 1-1.11 Calculation grid

2) Analysis conditions

i) Water channel cross-section, etc.

The water channel cross-sections and intake facilities in the unsteady flow analysis were the same as those in the non-uniform flow analysis previously described. However, the effect of the bridges, including the roughness coefficient was estimated in order to reproduce the steady conditions in the non-uniform flow analysis.

The analysis conditions such as discharge, water levels, etc., were as follows.

The design discharge 474m^3/s was taken at the Ibrahimia Head regulator, and the design 19m^3/s was taken at the Ibrahimia canal. At the upstream point of the DGRs, 455m^3/s was maintained at the design control water level 46.3m, and it was assumed that the water was divided into 7 channels. Then a scenario was envisaged where one of the Bahr Yusef regulator gates (4 gates, 227m^3/s) was closed for some reason, and it was not possible to distribute 57m^3/s. The variations over time in the upstream water levels of the regulator in this scenario were analyzed.

Table 1-1.11 Discharge and water level conditions

Ibrahimia Head Regulator design amount	474m^3/s
Ibrahimia Canal design intake	19m^3/s
Bahr Yusef Regulator upstream design discharge	455m^3/s
Bahr Yusef Regulator upstream design control water level	46.3m

1-2 Evaluation of analysis results

(1) Non-uniform flow analysis

a) Analysis results

With the construction of the new DGRs, the control water level upstream of the regulators will be increased from the previous maximum of 46.10m to 46.30m, an increase of 0.2 m. Therefore this analysis determined whether or not there was an effect associated with the construction of the new regulator group. The range and scale of the potential effect were then estimated. The applicable discharges were the Ibrahimia intake design discharge of 474m^3/s, Ibrahimia canal design intake discharge of 19m^3/s, and DGRs upstream discharge of 455m^3/s.

The results of the water surface profile analysis conducted at the present and in the design are shown in Table 1-2.1 and Figure 1-2.1 The increase in water level of the DGR upstream is 0.20m, which becomes 0.05m at a point downstream of the Ibrahimia intake, which is a small difference. It was found that the effect on the water surface profile extended downstream of the Ibrahimia Head regulator.

Table 1-2.1 Analysis result (n=0.0256)

Item	Ibrahimia Head regulator design discharge (m^3/s)	DGRs upstream water level (m)	Ibrahimia Head regulator downstream calculated water level (m)
Present status	474	46.10	50.16
Plan		46.30	50.21
Increase in water level (m)	-	0.20	0.05

The enlarged view of the water level is shown in Figure 1-2.2. In the upstream section where the elevation of the canal bed is relatively low, the water level rises mild. On the other hand, in the sections from DGRs until 20km upstream where the elevation of the canal bed is high, the water level rises relatively steep. This means that the sections until 20km from DGRs has a difficulty in flowing a result of sedimentation.

The difference in water levels between the present situation and the plans shrinks in the section 20km upstream of the Ibrahimia Head regulator. This phenomenon is likely due to sedimentation.

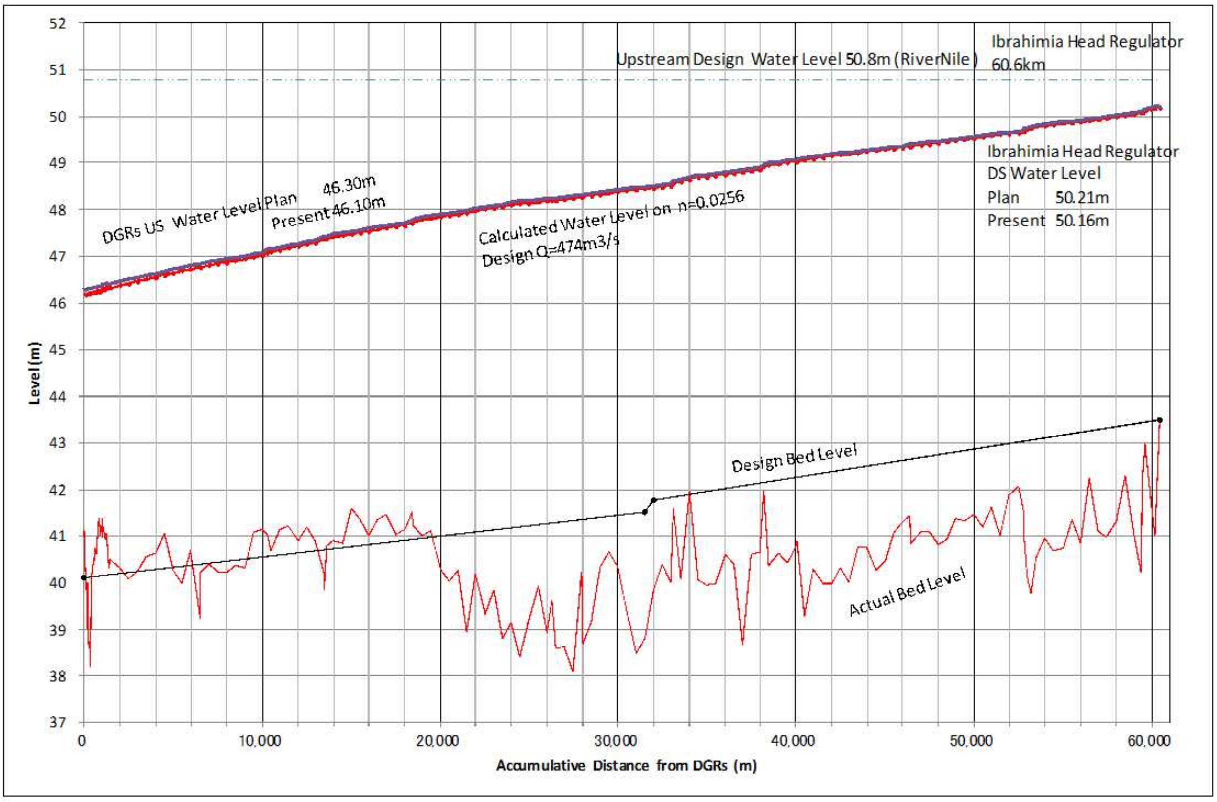


Figure 1-2.1 Water surface profile analysis in present situation and the design water level with the design discharge

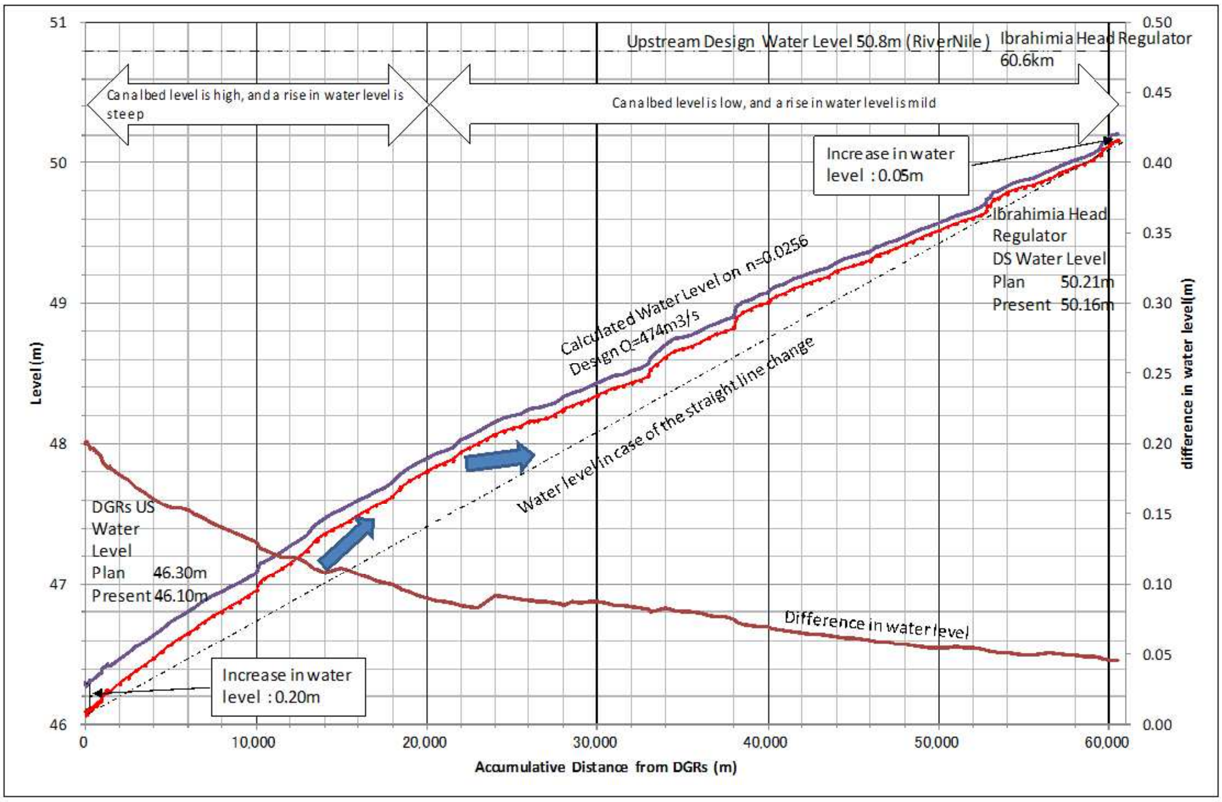


Figure 1-2.2 Water surface profile analysis in present situation and the design water level with the design discharge (enlarged view)

b) Evaluation

The difference in the water levels from the water surface profile, associated with the construction of the NDGRs is 0.20m upstream of the DGRs, but decreases to 0.05m at the downstream of the Ibrahimia Head regulator. Also, as shown in Figure 1-2.3, by comparing the water levels under design conditions with the elevation of the levees, it is found that there are no locations at risk of overtopping the current banks.

From the above, the construction of the NDGRs is considered to have almost no effect on the water surface profile.

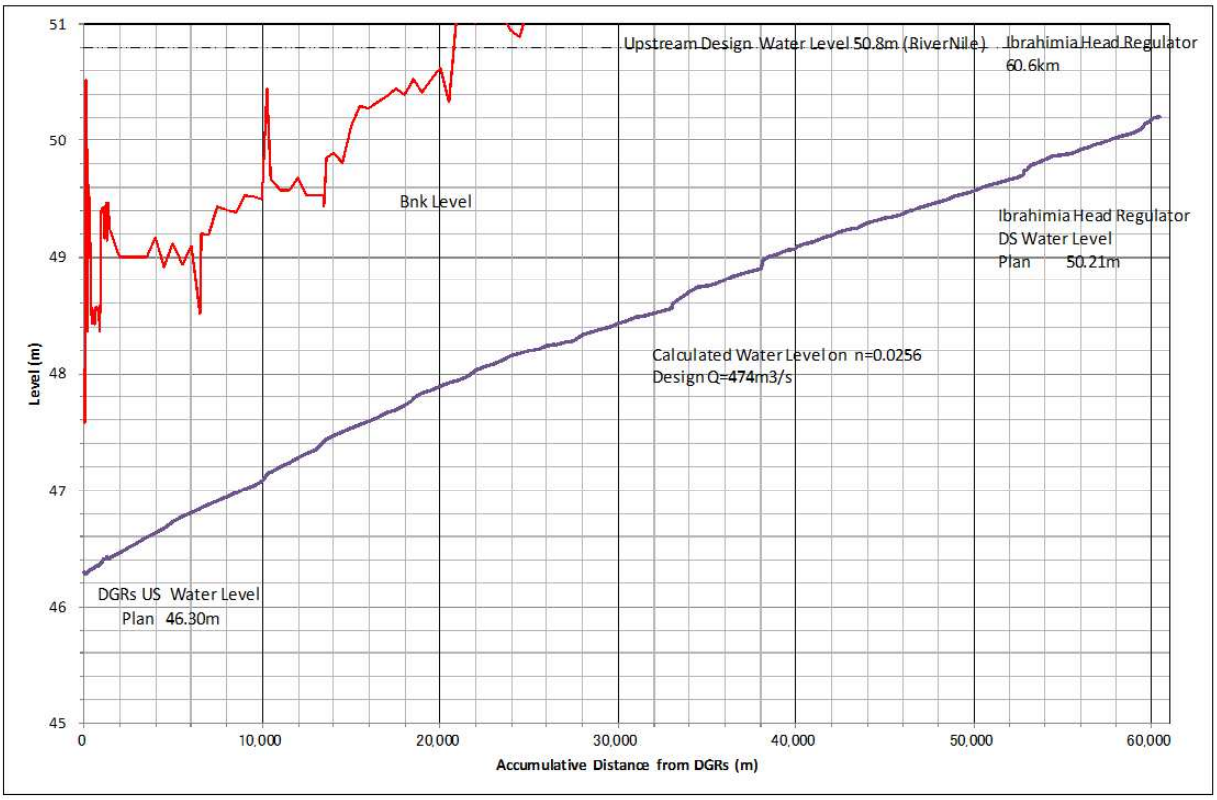


Figure 1-2.3 Comparison of the water surface profile under design conditions with the levee elevations

(2) Unsteady flow analysis

a) Analysis results

At design discharge distribution of 455m^3/s, when one gate of the Bahr Yusef regulator is closed, the 227m^3/s distribution drops to 170m^3/s, and the 57m^3/s difference is stored upstream of the regulator. As a result, the upstream water levels at the regulator increase, as does the quantity distributed to the other regulators.

Figure 1-2.4 shows the upstream water levels at the regulator: before the closure of the gate, 30 minutes, 1 hour, and 12 hours after the closure of the gate.

After the closure of one gate, the regulator upstream water level rises to EL.46.47m after 30 minutes, EL.46.53m after 1 hour, and EL.46.84m after 12 hours. These are rises in water level of 0.17 m, 0.23 m, and 0.54m respectively. The effect of the rise in water level after 12 hours extends downstream of the Ibrahimia Head regulator.

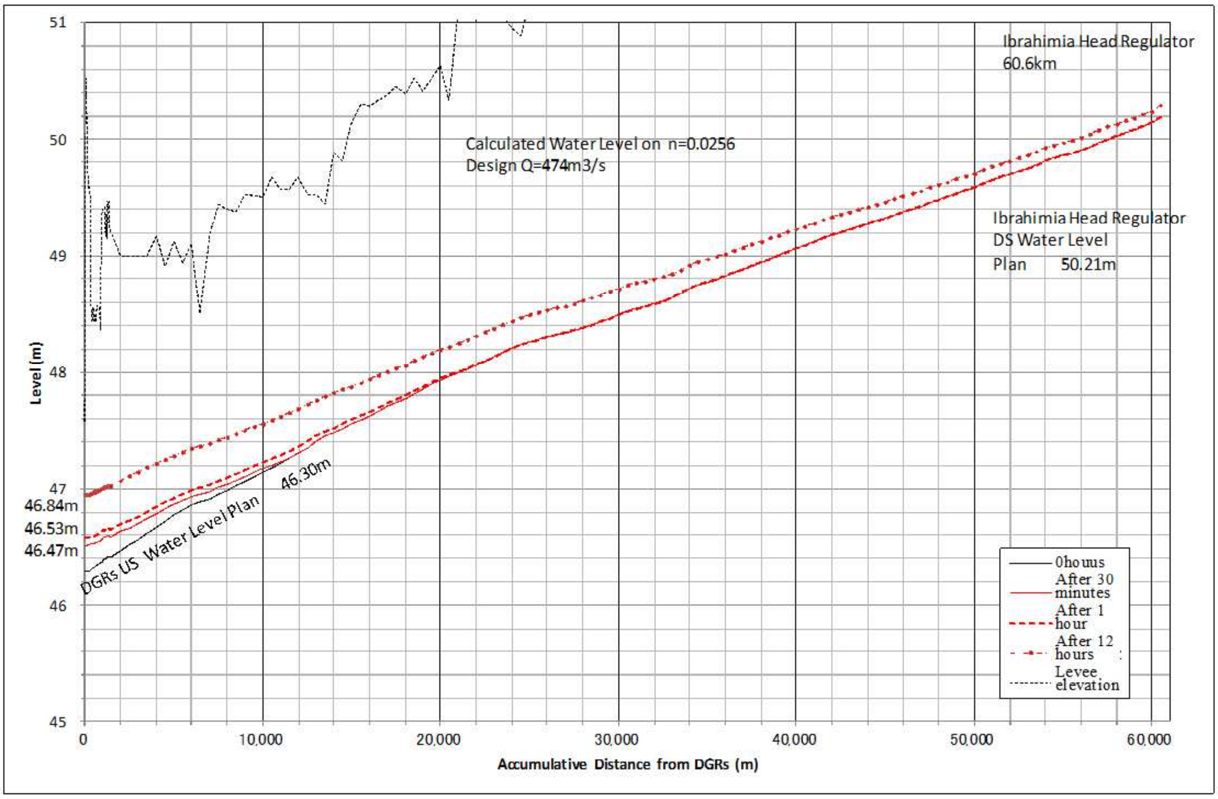


Figure 1-2.4 Water level profile at the upstream of the regulator after closure of one gate

b) Evaluation

One hour after one gate of the Bahr Yusef regulator is closed under the design discharge, there is a possibility of a 23cm rise in upstream water level at the regulator due to the impact of the water surface profile. After 12 hours this becomes 0.54m, and in both cases no overtopping of banks occurs.

It is therefore important that the initial response system be activated promptly after the closure of a gate. This includes the activation of the flood spillway located on the right bank 1.3km upstream of the regulator, and the reduction of the intake amount at the Ibrahimia intake.

Reference 1: Relationship between water surface profile level and canal shoulder level

Examining the relationship between the water surface profile level and the canal shoulder level identified one place (No.56 in the figure below) 14.5km upstream of the DGR where water level exceeds the canal shoulder level.

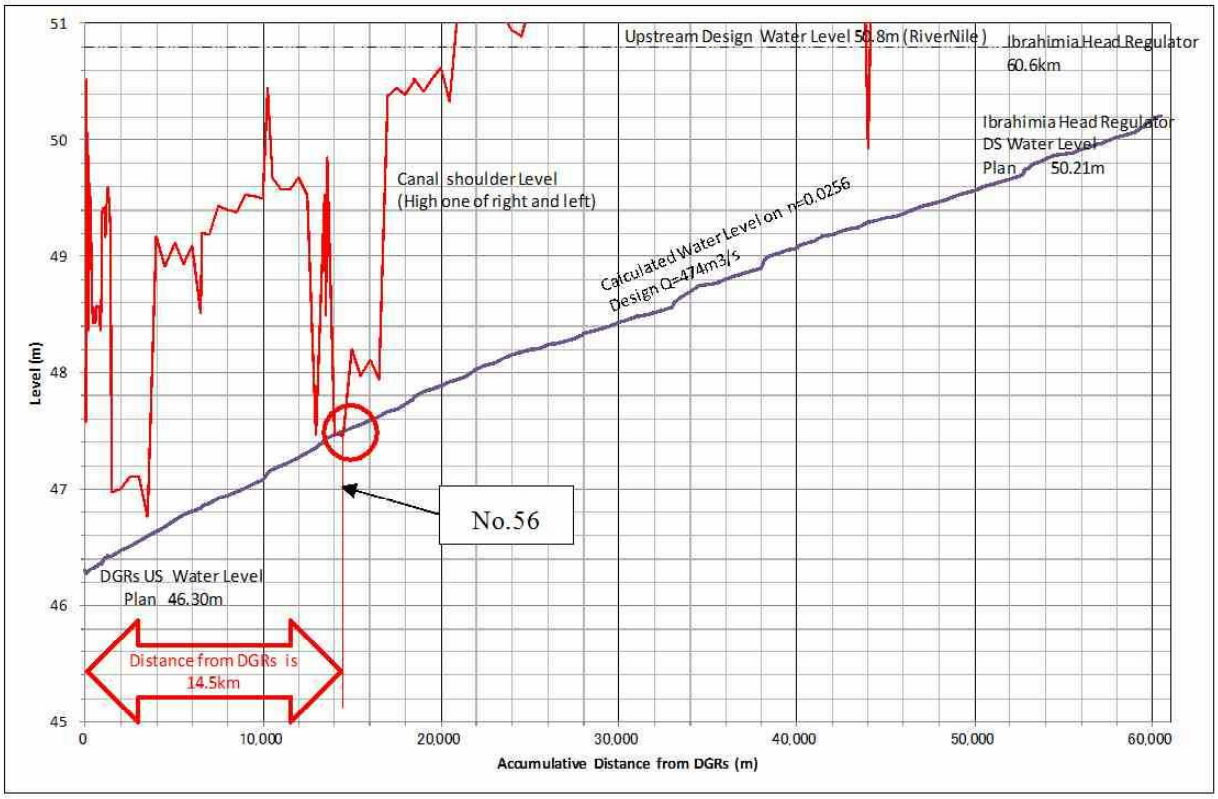


Figure 1-2.5 Critical point where water level exceeds canal shoulder

Estimated rise in water level is 11cm from the actual maximum water level after the construction of NDGRs, as shown in Figure 1-2.6.

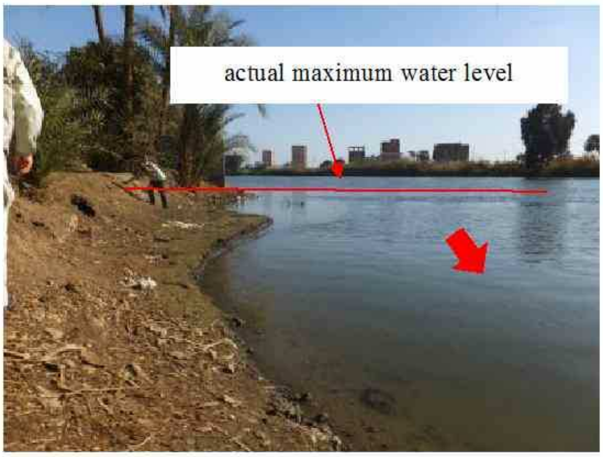


Figure 1-2.6 Current maximum water level at the critical point

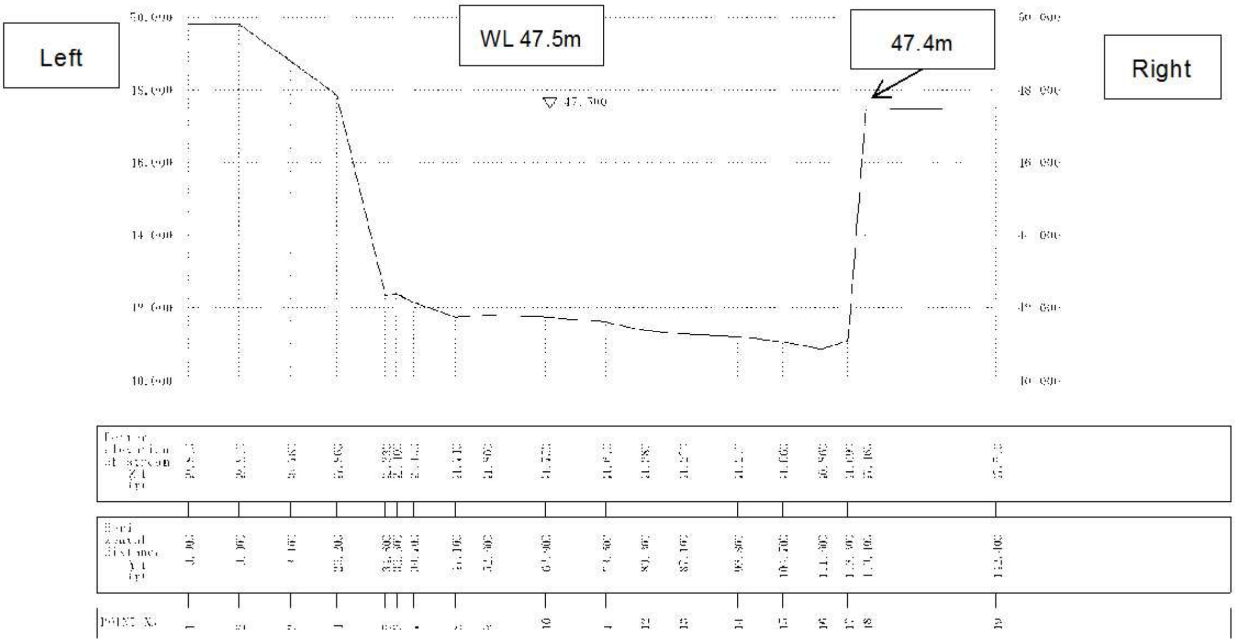


Figure 1-2.7 Maximum water level at cross section No.56 (14.5km U/S of DGRs)

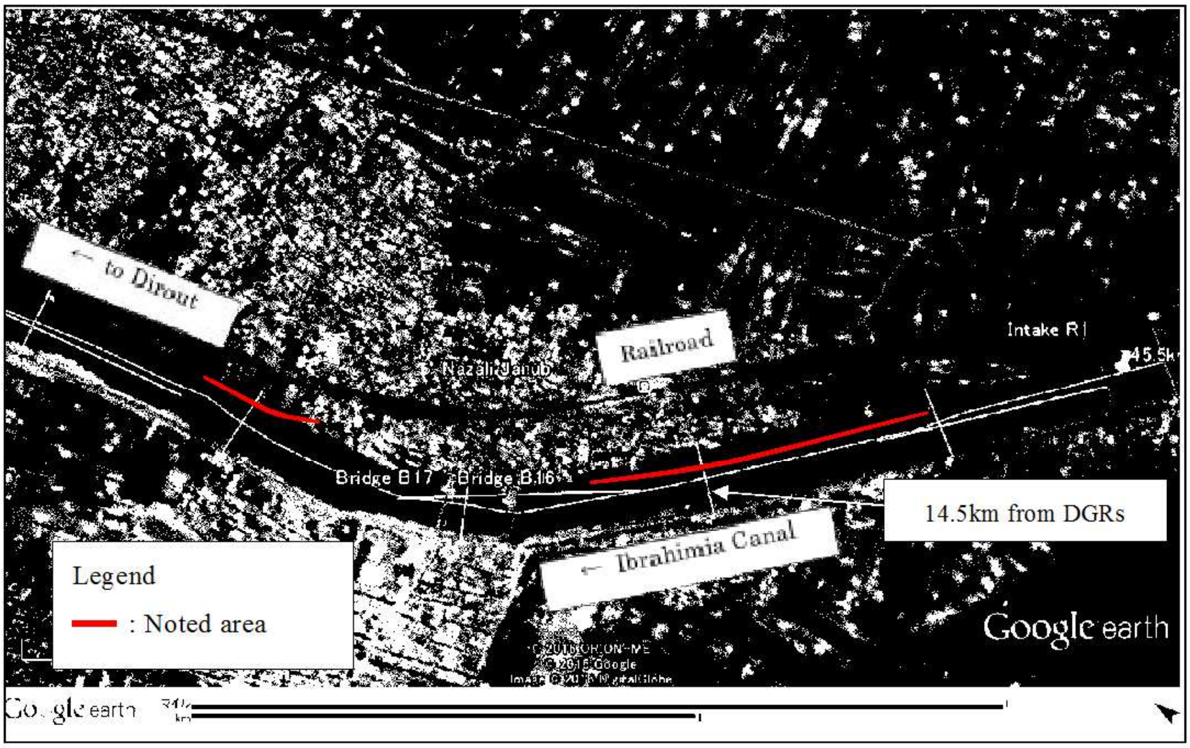


Figure 1-2.8 Critical point where water level exceeds canal shoulder

2. Mathematical Model Analysis

2-1 Object and method of analysis

(1) Analysis objective

As different water volumes need to be distributed evenly and accurately to seven main canals by five regulators in the NDGRs, an analysis of flow conditions is conducted using a mathematical model to verify whether the NDGRs can demonstrate their necessary functions.

The concurrent operations of the gates, overflow and underflow, and the trends in sediment movement around the regulators are analyzed based on the results of the flow conditions analysis around the NDGRs. Then, the scouring and sedimentation phenomena upstream and downstream of the regulators are evaluated.

The analysis of the flow conditions around the NDGRs has two objectives, as described above:

1. In the flow analysis: the accurate recreation of the effects of mathematical flow conditions around the existing and new regulators and the changes in flow conditions due to multi-directional diversion.
2. In the riverbed variation analysis: A quasi three-dimension (Q3D) mathematical model shall be used in the flow condition analysis, taking into consideration the suspended sediment concentration and non-equilibrium of changes in water depth.

The results of the physical hydraulic model test conducted by HRI will be separately verified and reflected in the design. The same values of the physical hydraulic model test are applied-as far as possible-to the basic conditions for analyzing the topography, discharge, etc. in the flow analysis.

And, in the riverbed variation analysis, it was carried out using existing data. However, since sufficient accuracy has not been obtained to grasp the annual sediment volume, the result of the accuracy required for examining the countermeasure work has not been obtained. Here, it shows analysis results using existing data.

(2) Target of the analysis

The target of the analysis is the same area shown in the plane survey in Figure 2-1.1, including the DGRs and the NDGRs.

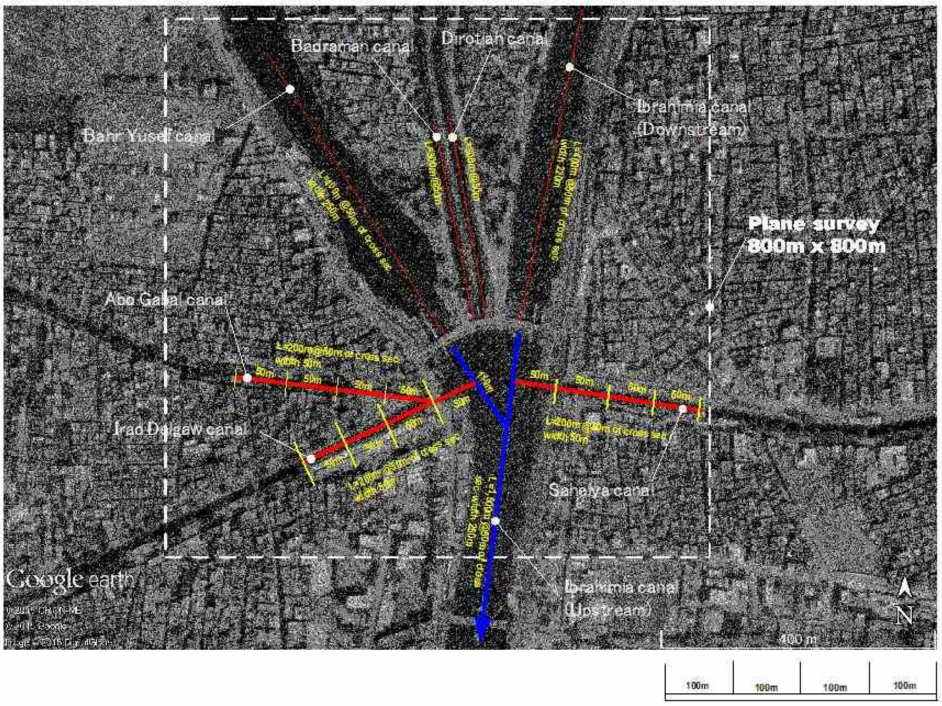


Figure 2-1.1 Scope of analysis

(3) Analysis method

a) Flow Analysis

1) Selection of applicable mathematical model

Mathematical hydraulic analysis of the NDGRs requires not only the evaluation of the flow in the downflow and transverse directions of the canal, but also the evaluation of the depth direction. For this reason, it is necessary to adopt either a Q3D (plane two-dimensional multilayer) calculation model or a three-dimensional calculation model.

As a result of comparing and reviewing the features of mathematical models, the Q3D calculation model was adopted for its ability to evaluate flow in the depth direction with the same accuracy as the three-dimensional calculation model, while requiring less input data and computation time than the three-dimensional calculation model.

Table 2-1.1 Comparison of mathematical models

Item	**Q3D Model**	**3D Model**	**Remarks**
1. Calculable items			
Flow velocity in downflow direction (u)	Available		
Flow velocity in transverse direction (v)	Available		
Flow velocity in depth direction (w)	Available		
2. No. of input data	Few (Good)	Many (Acceptable)	
3. Accuracy of calculation results	Almost the same		
4. Computation time (*)	1 (Good)	10 (Not good)	Relative ratio when computation time of quasi-3D model is taken as 1
5. Expression of results	Almost the same		
Overall evaluation	Excellent	Acceptable	

(*): Ottevanger, W, Uijttewaal, WSJ & Blanckaert, KJF (2012). Quasi-3D modelling of bed shear stresses at high curvature. In R Murillo Munoz (Ed.), River Flow 2012: Proceedings of the sixth edition of the international conference on fluvial hydraulics (pp. 775-782). London: Taylor & Francis Group.

2) Basic equations of analysis model

The Q3D model is a technique developed to obtain the same results as a three-dimensional model by applying approximate solutions in order to ease the computational load experienced in three-dimensional models.

The basic equations applied are described below in i-iv.

i) Features of analysis model

The features of the analysis model are shown in Table 2-1.2.

Table 2-1.2 Features of analysis model

Item	Features
Calculation variables	Flow velocity and water level are calculated
Calculation dimension	Water body is calculated in three dimensions
Hydrostatic approximation	As the water body is extensive in the horizontal direction and the vertical flow velocity is very small compared with the horizontal flow velocity, only hydrostatic pressure is taken into consideration
Viscosity and diffusion terms	Horizontal direction: SGS model is applied Vertical direction: Mellor & Yamada 2.5-order turbulence model is applied
Coordinate system	To fully reflect the complex and irregular topographical conditions, orthogonal curvilinear coordinate system is adopted in the horizontal direction, and σ-transformation is used to appropriately evaluate free water surface variation in the vertical direction.

ii) Basic equations

The basic equations are shown below. There are four equations in two types:

1. Continuity equation

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$

2. Navier-Stokes (N-S) equations

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}-fv=-\frac{1}{\rho}\frac{\partial P}{\partial x}+\frac{\partial}{\partial x}\left(\upsilon_x\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial x}\left(\upsilon_y\frac{\partial u}{\partial y}\right)+\frac{\partial}{\partial x}\left(\upsilon_z\frac{\partial u}{\partial z}\right)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}-fu=-\frac{1}{\rho}\frac{\partial P}{\partial x}+\frac{\partial}{\partial x}\left(\upsilon_x\frac{\partial v}{\partial x}\right)+\frac{\partial}{\partial x}\left(\upsilon_y\frac{\partial v}{\partial y}\right)+\frac{\partial}{\partial x}\left(\upsilon_z\frac{\partial v}{\partial z}\right)$$

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}=-\frac{1}{\rho}\frac{\partial P}{\partial x}+\frac{\partial}{\partial x}\left(\upsilon_x\frac{\partial w}{\partial x}\right)+\frac{\partial}{\partial x}\left(\upsilon_y\frac{\partial w}{\partial y}\right)+\frac{\partial}{\partial x}\left(\upsilon_z\frac{\partial w}{\partial z}\right)-g$$

Where,

u, v, w: Flow velocities (m/s) in x, y, z directions
P : Pressure (Pa)
g : Gravitational acceleration (m/s^2)
f : Coriolis parameter (rad/s)

υ_x, υ_y, υ_z: Turbulent eddy viscosity coefficient (m^2/s)

The turbulent eddy viscosity coefficient and eddy diffusion coefficient are given by the turbulence model described later.

iii) Coordinate system

The boundary-fitted orthogonal curvilinear coordinate system (Figure 2-1.2) is used for the horizontal coordinate system. σ-transformation is used (Figure 2-1.3) for the vertical coordinate system. The topography of curved river channels and coastlines can be expressed by orthogonal curvilinear coordinates. σ-transformation is a coordinate system where σ = 1 at the water surface and σ = 0 at the bottom. Expanding and contracting the vertical coordinates to suit the topography, enables complex topography to be expressed more naturally.
Conversion from Cartesian coordinates to σ-coordinates is defined by the following equation.

$$\sigma = \frac{z - \eta}{h + \eta}$$

Where,

x, y, z : Coordinates in the Cartesian coordinate system

$H \equiv h + \eta$

$h(x, y)$: Coordinates for the bottom

$\eta(x, y, z)$: Surface variation

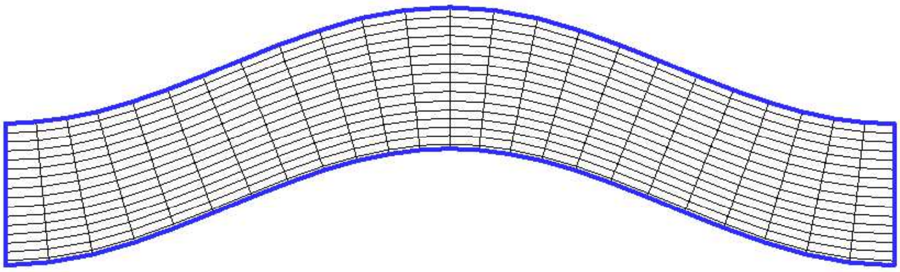


Figure 2-1.2 Orthogonal curvilinear coordinate system

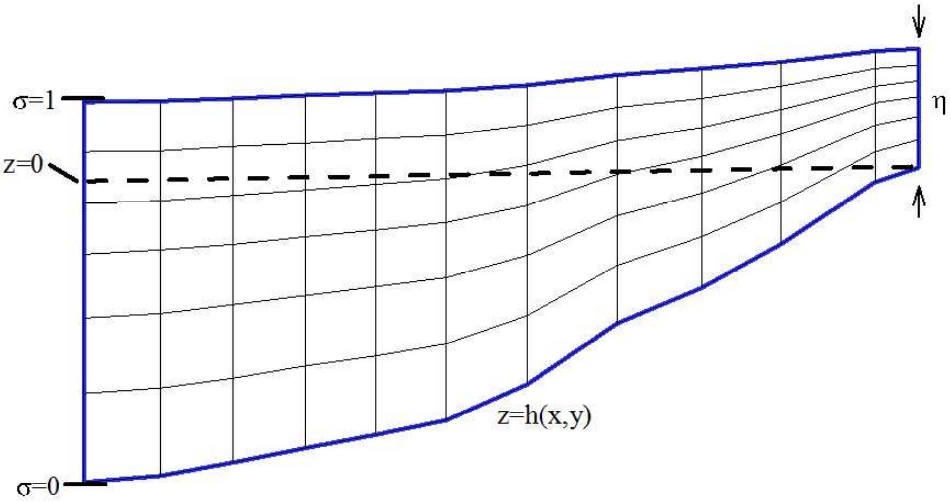


Figure 2-1.3 σ-coordinate system

iv) Turbulence model

The vertical turbulent eddy viscosity coefficient and vertical diffusion coefficient are obtained by the level 2.5 anisotropic second-order turbulence closure model. The stratification in the vertical direction and its effect on diffusion can be expressed in detail by the vertical turbulent eddy viscosity coefficient and vertical diffusion coefficient modeling.

3) Analysis conditions

i) Calculation meshes

Calculation meshes were created to appropriately express the shape of the distributing part and the regulator group.

The calculation mesh size in the longitudinal and transverse direction was set from 0.5m to 2.5m to enable detailed study of the flow fields especially around the newly constructed regulators.

To reduce the computational load, the calculation mesh size in the longitudinal direction was changed to between 2.5m and 10m for the upstream and downstream river channels.

As for the mesh division in the vertical direction, the channel was divided into five parts; from the deepest part to the water surface.

The meshes were deployed in line with the canal shape to recreate the Bahr Yusef, Ibrahimia, Abo Gabal, Irad Delgaw, and Sahelyia canals.

There are 218 meshes in total in the longitudinal direction x, 182 in the transverse direction x, and 5 in the vertical direction. These are 198,380 in total. The calculation mesh size of the entire area is roughly 4m in the longitudinal direction x, and 2.5m in the transverse direction.

The created calculation meshes are shown in Figure 2-1.4.

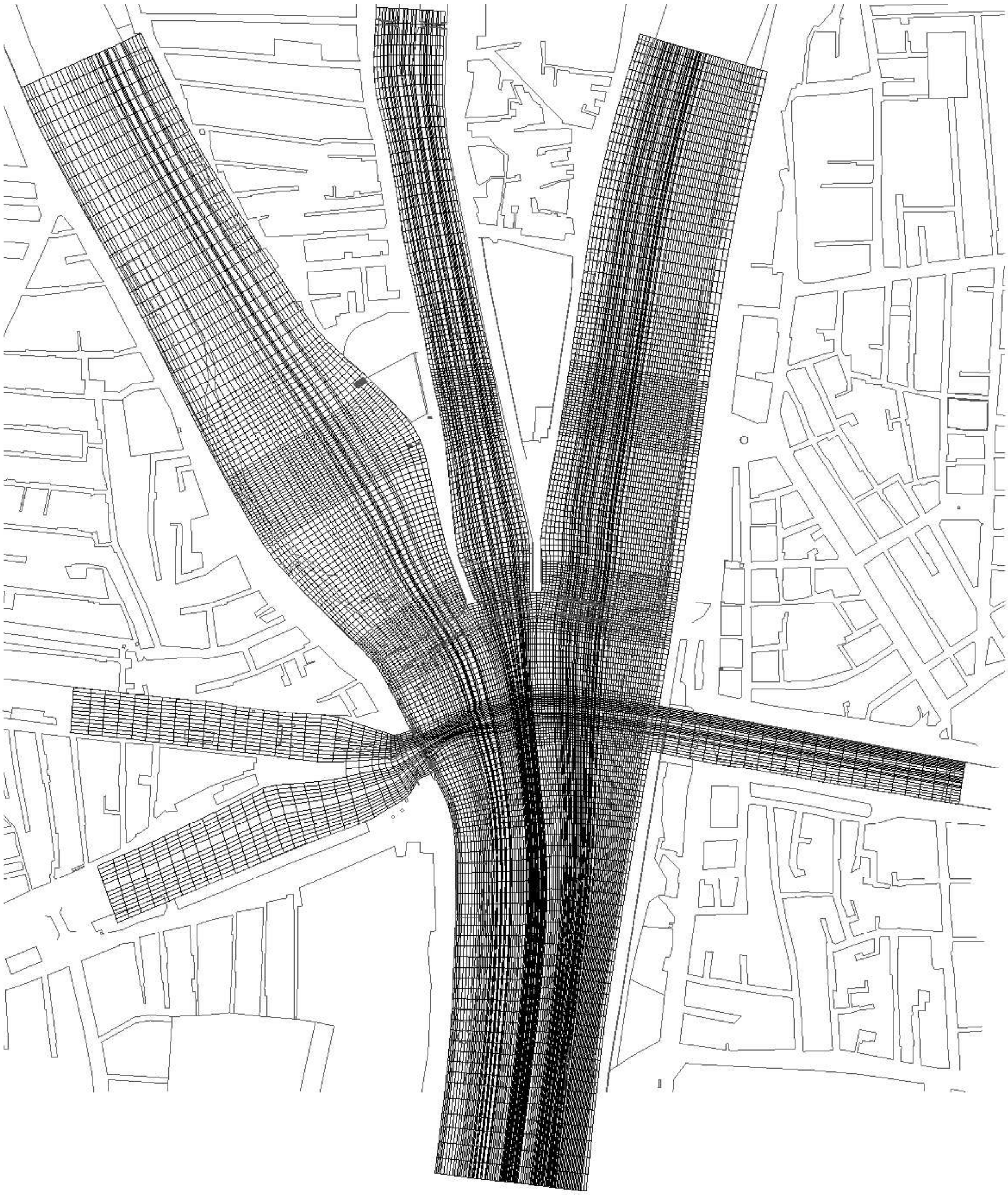


Figure 2-1.4 Canal meshes

ii) Topography

The following two topographies were used.

1. Topography surveyed in August 2015: The same calibration data as the physical hydraulic model test conducted by the HRI was used to verify the flow analysis.
2. Topography surveyed in January 2016: The topographic map after sediment removal was used in the design of the NDGRs and to evaluate the impact of constructing the regulators.

The created two-dimensional topographic plans are shown in Figure 2-1.5 and Figure 2-1.6.

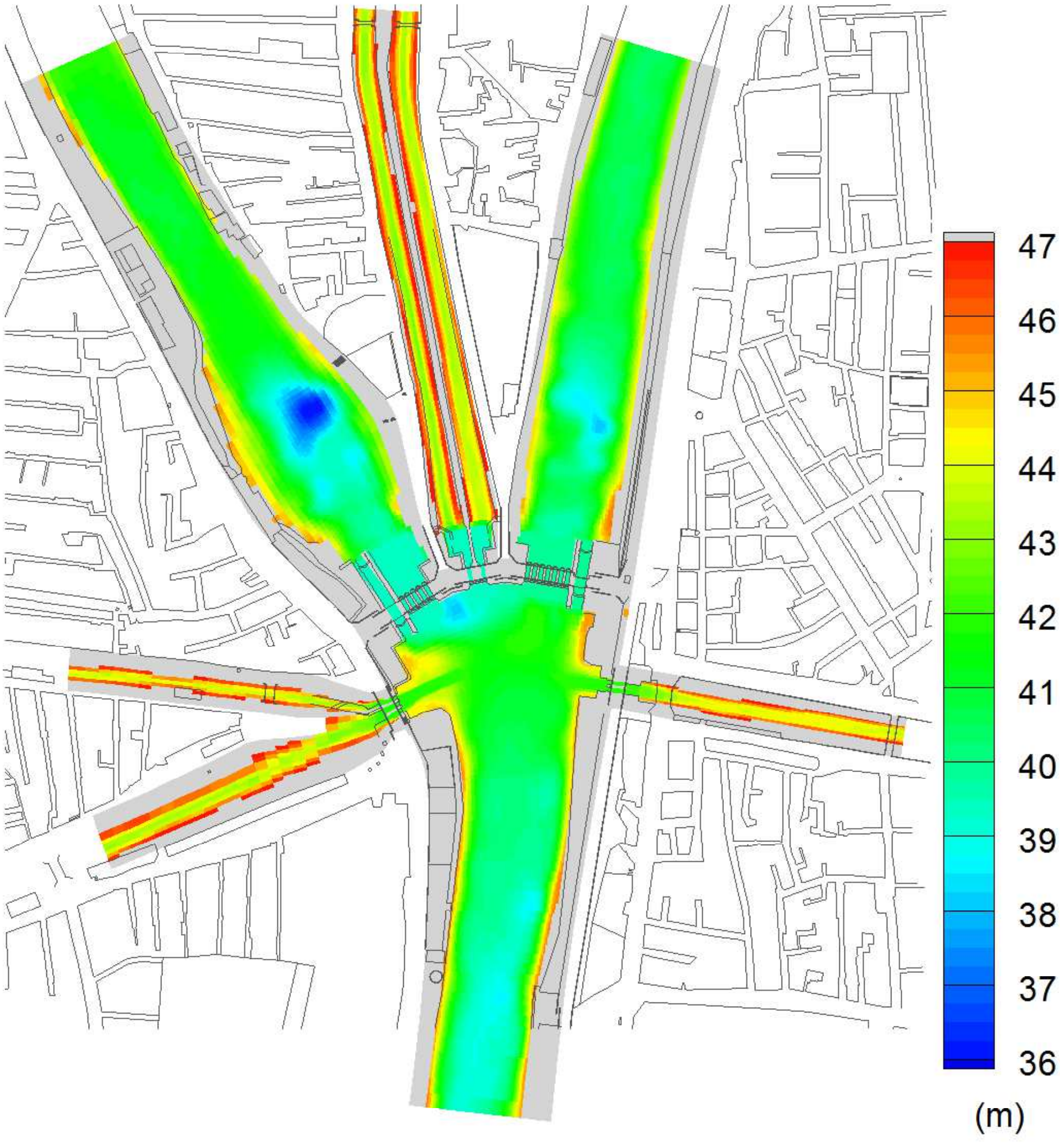


Figure 2-1.5 Contour map of canal bed (surveyed in August 2015)

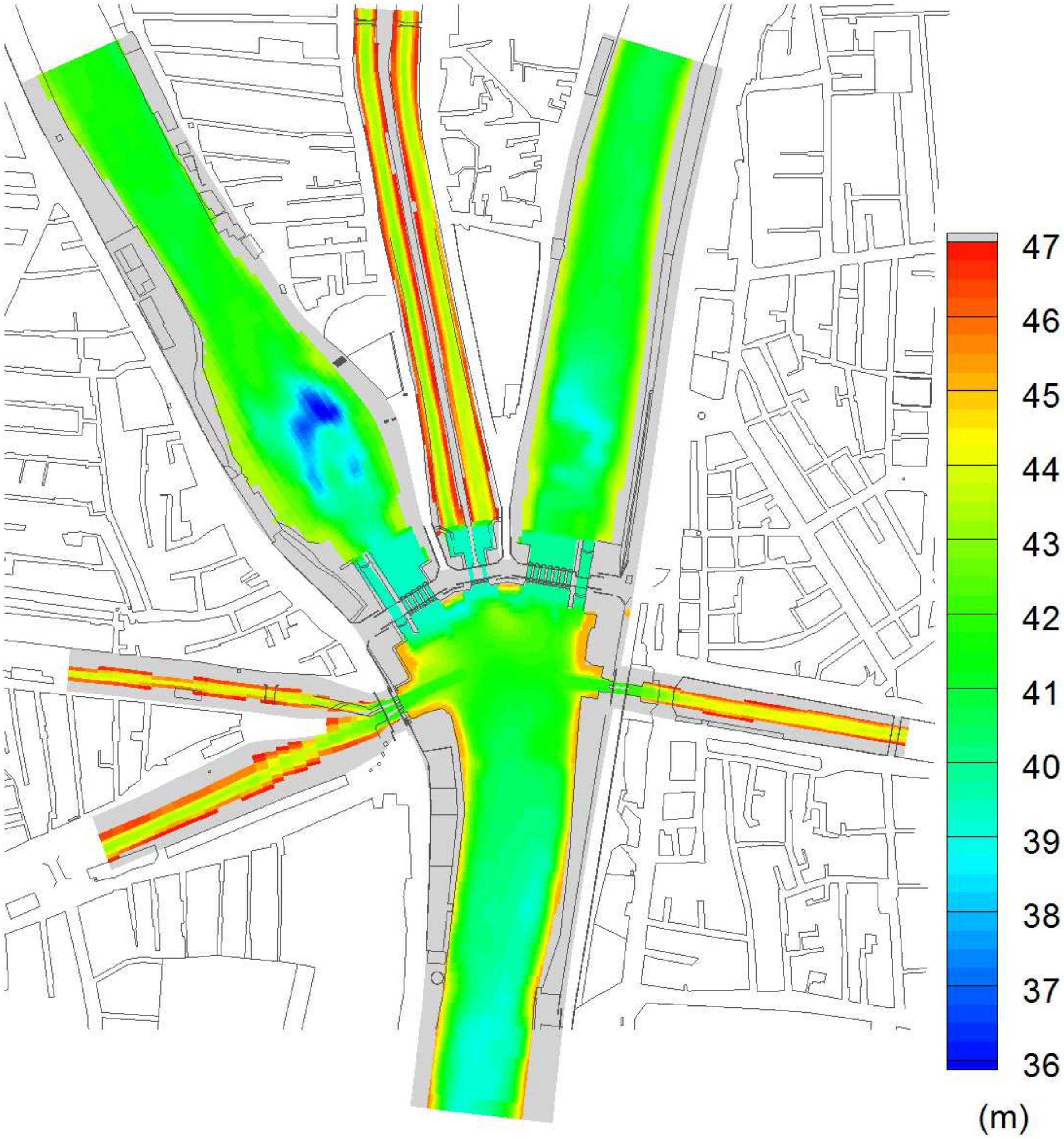


Figure 2-1.6 Contour map of canal bed (surveyed in January 2016)

Current dimensions of DGRs is shown in the following table.

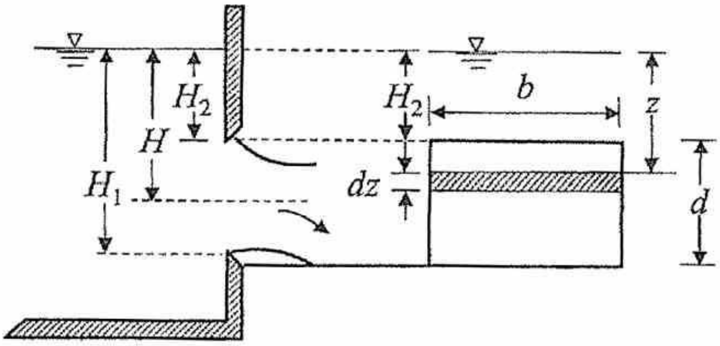
Table 2-1.3 Current dimensions of DGRs

Name of canal at DGR		Structural dimensions		Gate dimensions
Downstream side of DGR	Bahr Yusef	No. of gate Pier Mid. apron Foundation Lock	5 vents 4 units & width 1.80~2.25m L=43.25m, thickness 3m limestone partially concrete width 8.5m	3m width x 5 vents Total height 7.5m 3 leaves of gate Bottom elevation 39.50m Operational high water level 46.00m
	Ibrahimia	No. of gate Pier Mid. apron Foundation Lock	7 vents 6 units & width 1.80~2.25m L=39.70m, thickness 3m limestone partially concrete width 8.5m	3m wide x 7 vents Total height 7.5m 3 leaves of gate Bottom elevation 39.81m Operational high water level 46.00m
	Badraman & Dirotiah	No. of gate Pier Mid. apron Foundation	2 vents (1 vent closed) 2 units & width 1.80~2.25m L=38.65m, limestone, t=unknown	3m wide x 2 vents total height 7.5m 3 leaves of gate Bottom elevation 39.30 m Operational high water level 46.00m
Upstream side of DGR	Abo Gabal & Irad Delgaw (left bank)	No. of gate Pier Mid. apron Foundation	3 vents 2 units & width 1.80~2.25m L=28.60m limestone, t=unknown	3m wide x 3 vents Total height 5.5m 1 leaves of gate Bottom elevation 42.00 m Operational high water level 46.00m
	Sahelyia (right bank)	No. of gate Pier Mid. apron Foundation	2 vents 1 unit & width 1.80~2.25m L=18.90m, Limestone, t=unknown	3m wide x 2 vents Total height 5.5m 1 leaves of gate Bottom elevation 41.80 m Operational high water level 46.00m

iii) Outflow from regulators

The outflow from the DGRs was adjusted so that the measured water level and outflow matched the water level and diversion discharge of the analysis model for each canal. The adjustments were based on values calculated by the following overflow discharge equation, which itself was applied to the physical hydraulic model test conducted by the HRI.

$$Q = \frac{2}{3} C_1 \sqrt{2g} B (H_1^{3/2} - H_2^{3/2})$$



Where,

Q = Outflow (m^3/s)

C = Flow coefficient = 0.64

B = Regulator width (m)

g = Gravitational acceleration 9.8 (m^2/s)

H_1 H_2 = Water depth at the upstream and downstream of the orifice (m)

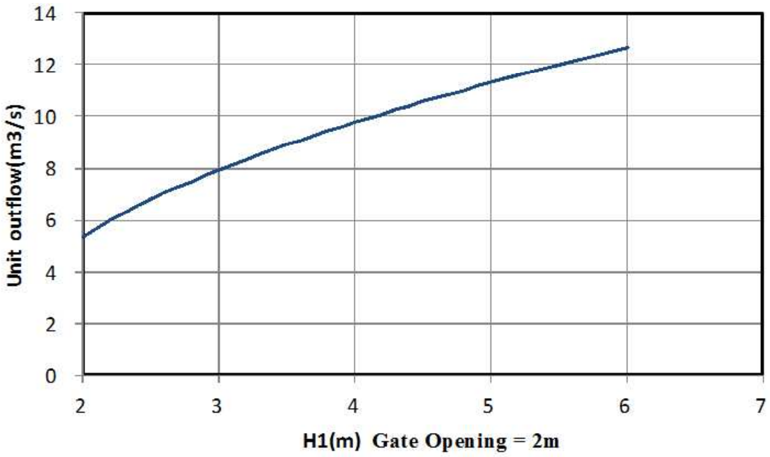


Figure 2-1.7 Rating curve of DGRs

The outflow from the NDGRs was adjusted so that the specified water level and outflow matched the water level and outflow of the analysis model for each canal. The adjustments were based on overflow values calculated by the overflow equation and underflow values calculated by the orifice equation.

Overflow equation

$$Q=C*B*H^{3/2}$$

Where:

Q = Outflow (m^3/s)

C = Flow coefficient

B = Regulator width (m)

H = the head over the gate (m)

Orifice equation (Underflow equation)

$$Q=\frac{2}{3}C_1\sqrt{2g}B(H_1{}^{3/2}-H_2{}^{3/2})$$

Where:

Q = Outflow (m^3/s)

C = Flow coefficient

B = Regulator width (m)

g = Gravitational acceleration 9.8 (m^2/s)

H_1 H_2 = Water depth at the upstream and downstream of the orifice (m)

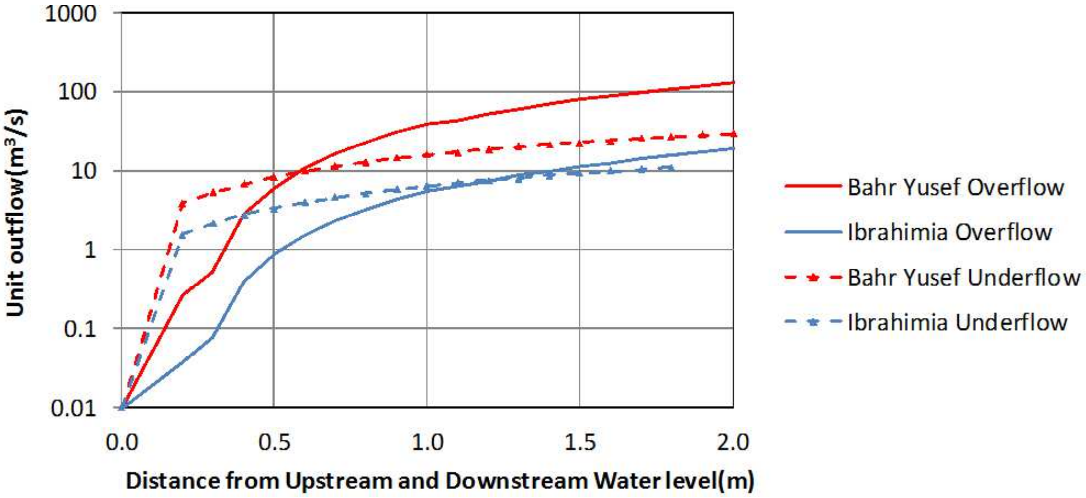


Figure 2-1.8 Rating curves of NDGRs (large regulators)

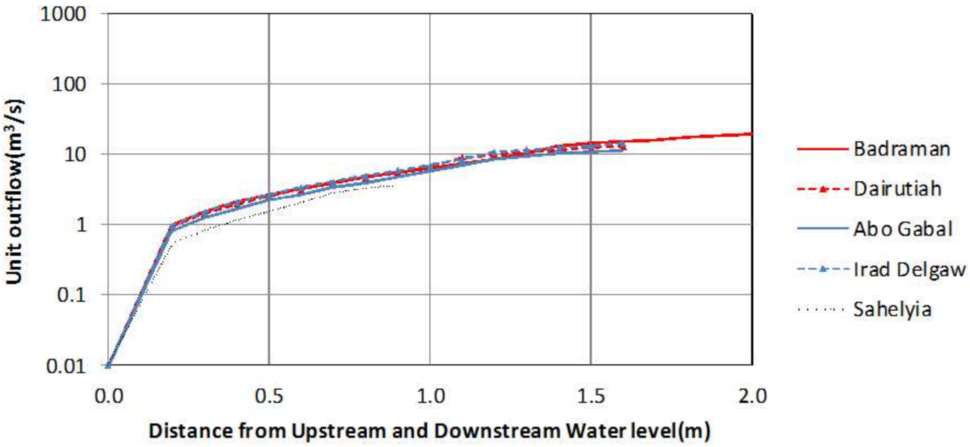


Figure 2-1.9 Rating curves of NDGRs (small regulators)

4) Boundary conditions

The outflow boundary at the upstream end of the Ibrahimia canal and the downstream ends of each of the canals were taken to be the water level boundaries.

5) Analysis cases

As shown in Table 2-1.4, the case analysis occurs in three stages: calibration, present state analysis, and planning.

1. At the calibration stage, the same topography, water level, and outflow values are measured against the results of the physical hydraulic model test conducted by the HRI.
2. Since the latest topographic data is applied to the design of the regulators in the present state and planning stages, the latest topographic data is applied to flow analysis.
3. At the planning stage, the gate discharge systems are analyzed to compare the differences in flow conditions at overflow and underflow.

The measured values (water level and discharge) obtained from the HRI (HRI surveyed and confirmed this data on 30th June 2015) are used for the model calibration. The design discharge is used at the present state and planning stages.

Table 2-1.4 Analysis cases

Analysis Case	Analysis Stage	Riverbed Condition	Facilities	Outflow(m^3/s) Measured 355m^3/s	Outflow(m^3/s) Design 455m^3/s	Remarks
Calibration	Calibration Stage	(1)	Existing (DGRs)	○		The same values as HRI are used for the water level and outflow.
Pesent State	Present state stage	(2)	Existing (DGRs)		○	
Planning 1	Planning stage	(2)	New Regulators (NDGRs) Gate:UnderFlow		○	
Planning 2			New Regulators (NDGRs) Gate:OverFlow		○	
Remarks	Reverbed Condition (survey data) (1):Aug,2015(HRI),(2):Jan,2016(D/D,HRI) (After Dredging)					

6) Water level, outflow, and gate opening by analysis case

The water level and outflow by analysis case are shown in Table 2-1.5, and the gate openings of calibration stage are shown in Table 2-1.6 and Figure 2-1.10.

Table 2-1.5 Water level and outflow by analysis case

Case	Outflow Condition	Upstream of Regulators		Downstream of Regulators						
		Ibrahimia		Bahr Yusef	Ibrahimia	Badraman	Dairutiah	Abo Gabal	Irad Delgaw	Saheleya
		Outflow (m^3/s)	Water Level (m)	Water Level (m)						
Calibration Stage	Calibration Outflow	355	46.02	45.82	45.05	45.68	45.88	45.73	44.79	45.72
Present State Stage	Design Outflow	455	46.30	45.82	45.13	45.90	45.90	45.90	45.90	45.90
Planning Stage	Desig Outflow	455	46.30	45.82	45.13	45.90	45.90	45.90	45.90	45.90

Table 2-1.6 Gate opening of calibration stage

Regulator		Gate Position	Gate Opening (m)						
			1	2	3	4	5	6	7
Bahr Yusef		Upper	N/A	N/A	N/A	N/A	N/A		
		Middle	2.25	2.25	2.25	2.25	2.25		
		Lower	0	0	0	0	0		
Ibrahimia		Upper	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Middle	2.00	2.00	2.00	2.00	2.00	2.00	2.00
		Lower	0	0	0	0	0	0	0
Badraman	Badraman	Upper	N/A						
		Middle	1.30						
		Lower	0						
	Dairutiah	Upper	N/A						
		Middle	0.875						
		Lower	0						
Abo Gabal	Abo Gabal		0.625						
	Irad Delgaw		0.15	0.15					
Sahelyia			0.10	0.10					

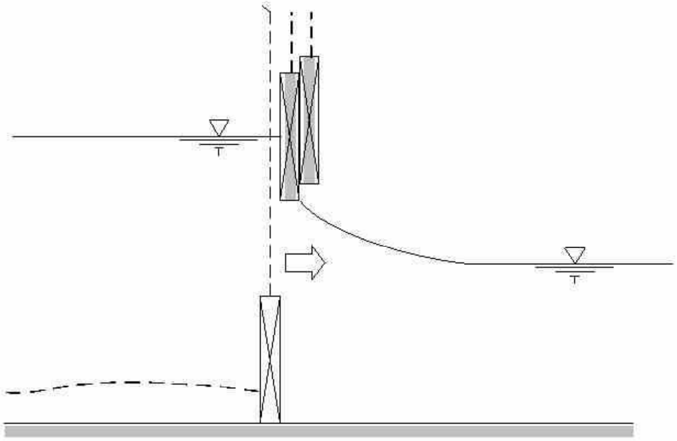


Figure 2-1.10 Gate opening at calibration stage at Bahr Yusef and Ibrahimia regulators

b) Riverbed variation analysis

1) Outline of riverbed variation analysis

As shown in Figure 2-1.11, riverbed variation analysis of the NDGRs is broadly divided into:

1. Flow calculation,
2. Calculation of riverbed variation and grain size distribution.

The mathematical hydraulic analysis model is applied to flow calculation.

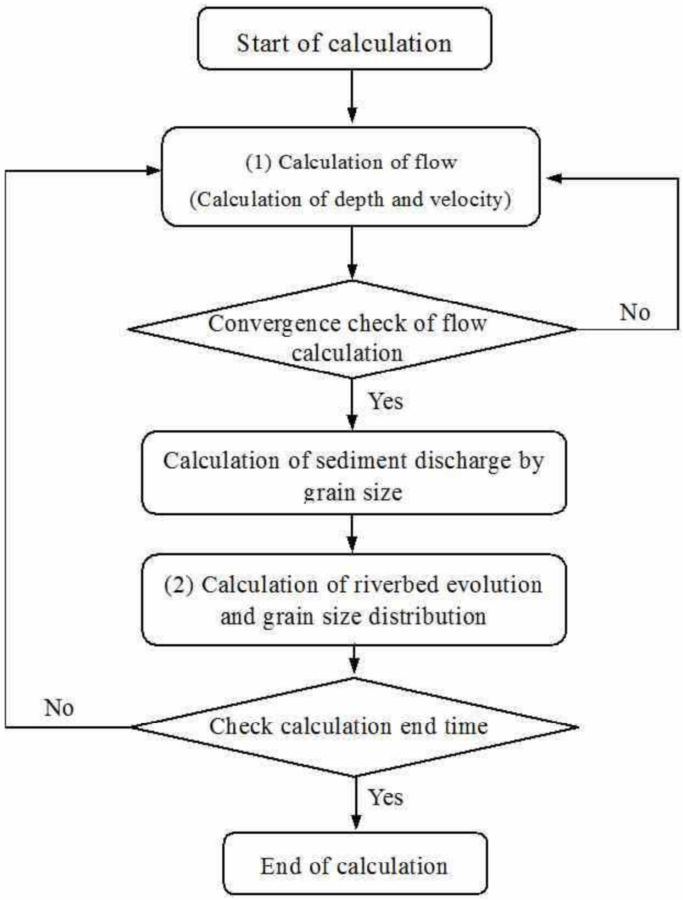

Start of calculation
(1) Calculation of flow
(Calculation of depth and velocity)
Convergence check of flow calculation
No
Yes
Calculation of sediment discharge by grain size
(2) Calculation of riverbed evolution and grain size distribution
No
Check calculation end time
Yes
End of calculation

Figure 2-1.11 Calculation flow of riverbed variation analysis

2) Basic equations of riverbed variation analysis

The basic equations for riverbed variation analysis, and those for calculating riverbed variation and grain size distribution, are described below in i-iii.

i) Calculation of riverbed variation

Riverbed variation is calculated using the equation below.

Bed load transport rate is calculated by the local change in bed load caused by the change in bed flow and also by the difference in suspended and settled bed material. The value of suspended bed material is calculated by solving the advection-diffusion equation shown later.

$$\frac{\partial z_b}{\partial t} = \frac{-1}{(1-\lambda)} \sum_k \left\{ \frac{\partial q_{bxk}}{\partial x} + \frac{\partial q_{byk}}{\partial y} + (E_{sk} - D_{sk}) \right\} \tag{1-1}$$

Where,

z_b: Elevation of riverbed

q_{bxk}: Bed load discharge of grain size k per unit width of x direction

q_{byk}: Bed load discharge of grain size k per unit width of y direction

E_{sk},D_{sk}: Rising and falling fluxes of the suspended load with grain size k

ii) Calculation of grain size distribution

The content of bed material at each grain size in the riverbed surface (transition layer) changes with riverbed fluctuations. It is calculated using the following equation.

$$\frac{\partial P_{bk}}{\partial t} - \frac{1}{E_m}\frac{\partial z_{bk}}{\partial t} + \frac{1}{E_m}\frac{\partial z_b}{\partial t}(\eta P_{bk} + (1-\eta)P_{bko}) = 0 \tag{2-2}$$

Where,

λ : Porosity of the bed material

P_{bk}: Percentage of D_k the grain in transition layer (also called the mixed layer)

P_{bko}: Percentage of D_k the grain in the bottom layer of the transition layer

E_m: Thickness of the transition layer

η : Identification factor with η = 0 in the case of erosion, η = 1 in the case of deposition, as shown in the following.

$$\eta = \begin{cases} 1 & \partial z_b / \partial t > 0 \\ 0 & \partial z_b / \partial t < 0 \end{cases} \tag{2-3}$$

The configuration of the riverbed is shown below in Figure 2-1.12. It is vertically divided into a number of layers from the reference plane z_o to the riverbed surface z_b. The top layer is a mixed layer with thickness E_m. The layer immediately below that is a transition layer with thickness E_t. The other layers are 'deposited layers,' all with the same thickness E_d.

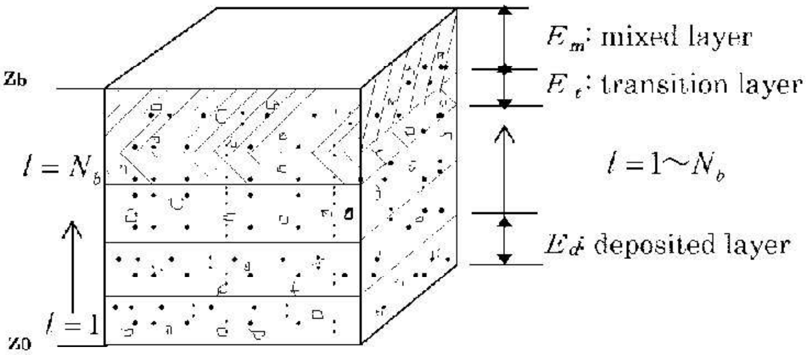


Figure 2-1.12 Riverbed formation

iii) Advection-diffusion equation

The advection-diffusion equation is shown below.

[Advection-diffusion equation: Suspended sediment concentration]

$$\frac{\partial C}{\partial t} + \frac{\partial uC}{\partial x} + \frac{\partial vC}{\partial y} + \frac{\partial wC}{\partial z} = \frac{\partial}{\partial x}(D_{Ch}\frac{\partial C}{\partial x}) + \frac{\partial}{\partial y}(D_{Ch}\frac{\partial C}{\partial y}) + \frac{\partial}{\partial z}(D_{Cz}\frac{\partial C}{\partial z})$$

Where,

C : Suspended sediment concentration (by grain size)

u, v, w : x, y, z -direction flow velocities

D_{Ch}, D_{Cz} : Effective (molecule + eddy) diffusion coefficient of water quality in horizontal and vertical directions

3) Analysis conditions

i) Mesh sizes

The mesh sizes are the same as those in the flow analysis.

ii) Computation period, water level, and discharge

Taking the riverbed in January 2016 to be the initial riverbed for calibration, calculations are made in November 2016, after 11 months of deposition. The riverbed surveyed in November 2015 is assumed to correspond to the riverbed after deposition in November 2016, and the calculation results are verified against the deposition and erosion trends in the surveyed riverbed from November 2015 to November 2016. Analysis of the water level and discharge is conducted using the average monthly values calculated from the measured values.

The actual discharges and water levels of the Bahr Yusef canal and the Ibrahimia canal for this period, were available. As Badraman, Diroutiah, Abo Gabal, Irad Delgaw, and Sahelyia canals are not monitored and the information unavailable, the discharge of each canal was computed using a percentage of the discharge and planned discharge of the Bahr Yusef and Ibrahimia canals mentioned above. The water level at the downstream end of each canal was given by the H-Q (Height-Discharge) relationship. The discharge is shown in Table 2-1.7 and Figure 2-1.13, and the water level is shown in Table 2-1.8 and Figure 2-1.14.

Taking the riverbed in January 2016 to be the initial riverbed for the calculation of predicted water levels and discharge, analysis was conducted with the given typical flow conditions for one year.

The average monthly discharge for 16 years from 1999 to 2014 was calculated to give the inflow, which was then distributed in proportion to the planned discharge. The discharge was calculated at the downstream end of each canal, and the water level at the downstream end of each canal was given by the H-Q relationship. The discharge is shown in Table 2-1.9 and Figure 2-1.15, and the water level is shown in Table 2-1.10 and Figure 2-1.16.

Table 2-1.7 Discharge used for calibration (January-November 2015)

Discharge(m^3/s)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov
Ibrahimia canal U/S	150.8	277.4	314.4	320.4	358.6	396.0	399.7	395.2	317.3	308.3	275.4
Bahr-Yusef canal	81.9	148.4	171.5	164.5	188.3	200.3	201.2	202.3	164.8	165.4	140.4
Ibrahimia canal D/S	52.6	99.1	109.0	121.4	131.6	153.0	155.4	150.3	118.3	109.7	105.3
Badraman canal	3.4	6.3	7.2	7.3	8.2	9.0	9.1	9.0	7.2	7.0	6.3
Diroutiah canal	4.6	8.4	9.6	9.8	10.9	12.1	12.2	12.0	9.7	9.4	8.4
Abo Gabal canal	2.7	4.9	5.6	5.7	6.4	7.1	7.1	7.1	5.7	5.5	4.9
Irad Delgaw canal	3.5	6.5	7.4	7.5	8.4	9.3	9.4	9.3	7.4	7.2	6.5
Saheleya canal	2.0	3.7	4.2	4.3	4.8	5.3	5.3	5.3	4.2	4.1	3.7

Table 2-1.8 Water level used for calibration (January-November 2015)

D/S Water level(m)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov
Ibrahimia canal U/S	44.2	45.5	45.7	45.7	45.8	46.0	46.0	46.0	45.7	45.6	45.6
Bahr-Yusef canal	42.2	44.9	45.3	45.2	45.6	45.8	45.8	45.8	45.2	45.2	44.7
Ibrahimia canal D/S	43.0	44.1	44.2	44.4	44.6	45.0	45.0	44.9	44.4	44.2	44.2
Badraman canal	44.1	45.5	45.5	45.5	45.6	45.6	45.7	45.7	45.5	45.4	45.5
Diroutiah canal	44.1	45.2	45.5	45.5	45.6	45.8	45.7	45.8	45.5	45.4	45.5
Abo Gabal canal	44.1	45.3	45.4	45.5	45.6	45.7	45.7	45.7	45.5	45.5	45.6
Irad Delgaw canal	44.1	44.6	44.6	44.7	44.7	44.8	44.8	44.7	44.6	44.5	44.6
Saheleya canal	44.1	45.4	45.6	45.5	45.6	45.8	45.7	45.8	45.5	45.5	45.6

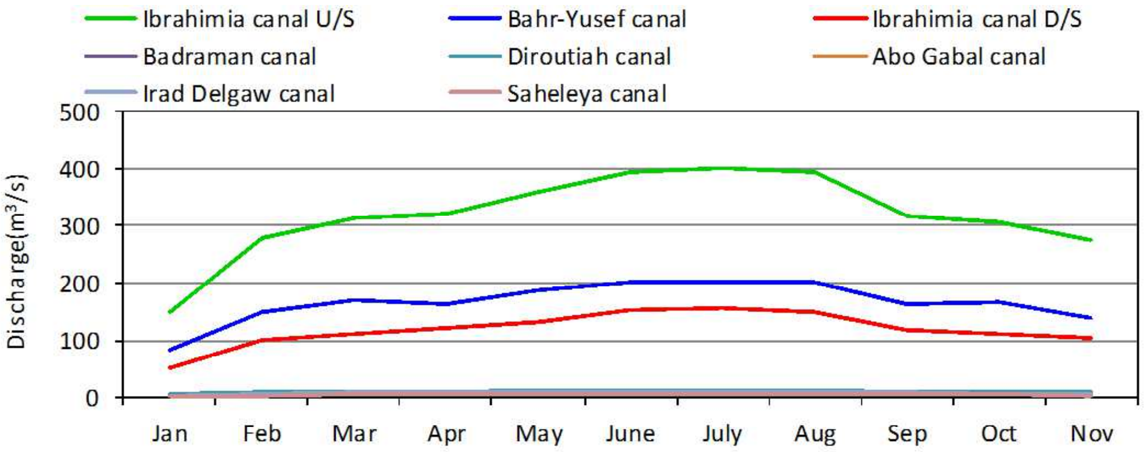


Figure 2-1.13 Discharge used for calibration (January-November 2015)

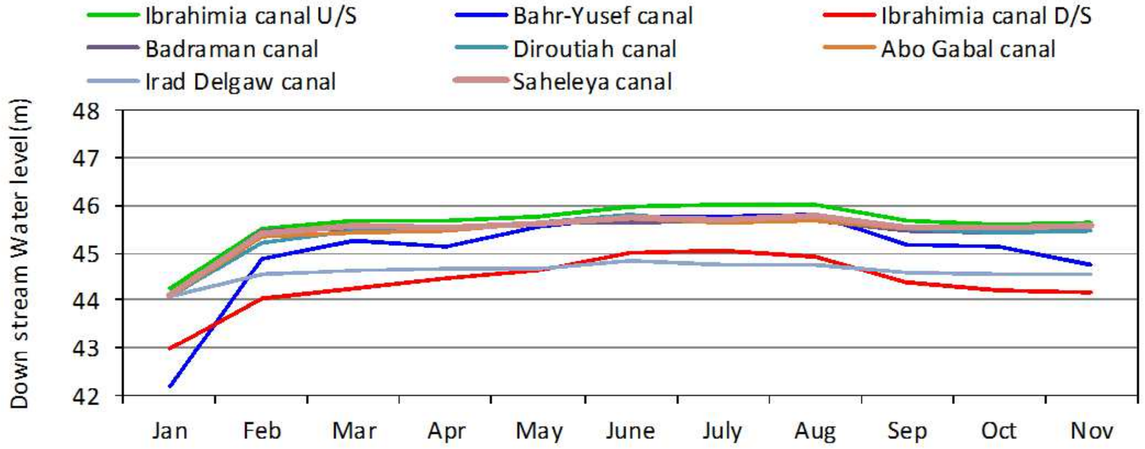


Figure 2-1.14 Water levels used for calibration (January-November 2015)

Table 2-1.9 Monthly discharge (predicted based on average monthly values from 1999 to 2014)

Discharge(m^3/s)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Ibrahimia canal U/S	111.0	286.9	323.9	339.6	345.2	411.3	418.1	414.7	340.7	316.1	285.8	226.4
Bahr-Yusef canal	51.0	141.0	164.0	167.0	171.0	203.0	206.0	206.0	166.0	150.0	139.0	103.0
Ibrahimia canal D/S	48.0	115.0	125.0	136.0	137.0	164.0	167.0	164.0	138.0	132.0	116.0	99.0
Badraman canal	2.5	6.5	7.4	7.7	7.9	9.4	9.5	9.4	7.7	7.2	6.5	5.1
Diroutiah canal	3.4	8.7	9.9	10.3	10.5	12.5	12.7	12.6	10.4	9.6	8.7	6.9
Abo Gabal canal	2.0	5.1	5.8	6.1	6.2	7.3	7.5	7.4	6.1	5.6	5.1	4.0
Irad Delgaw canal	2.6	6.7	7.6	8.0	8.1	9.6	9.8	9.7	8.0	7.4	6.7	5.3
Saheleya canal	1.5	3.8	4.3	4.5	4.6	5.5	5.6	5.5	4.5	4.2	3.8	3.0

Table 2-1.10 Monthly water level (calculated from Table 2-1.9)

D/S Water level(m)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Ibrahimia canal U/S	44.5	45.8	45.8	45.8	45.9	45.9	45.9	45.9	45.9	46.0	45.8	45.7
Bahr-Yusef canal	43.0	44.7	45.0	45.1	45.1	45.6	45.6	45.6	45.1	44.8	44.7	44.1
Ibrahimia canal D/S	42.7	44.2	44.4	44.5	44.6	44.9	45.0	44.9	44.6	44.6	44.2	44.0
Badraman canal	44.4	45.4	45.5	45.6	45.6	45.7	45.7	45.7	45.6	45.5	45.4	45.2
Diroutiah canal	44.3	45.4	45.6	45.6	45.6	45.7	45.7	45.7	45.6	45.5	45.4	45.1
Abo Gabal canal	43.9	44.8	44.9	45.0	45.0	45.2	45.2	45.2	45.0	44.9	44.8	44.5
Irad Delgaw canal	43.9	44.6	44.7	44.7	44.7	44.8	44.8	44.8	44.7	44.6	44.6	44.4
Saheleya canal	44.2	45.4	45.5	45.6	45.6	45.8	45.9	45.9	45.6	45.5	45.4	45.0

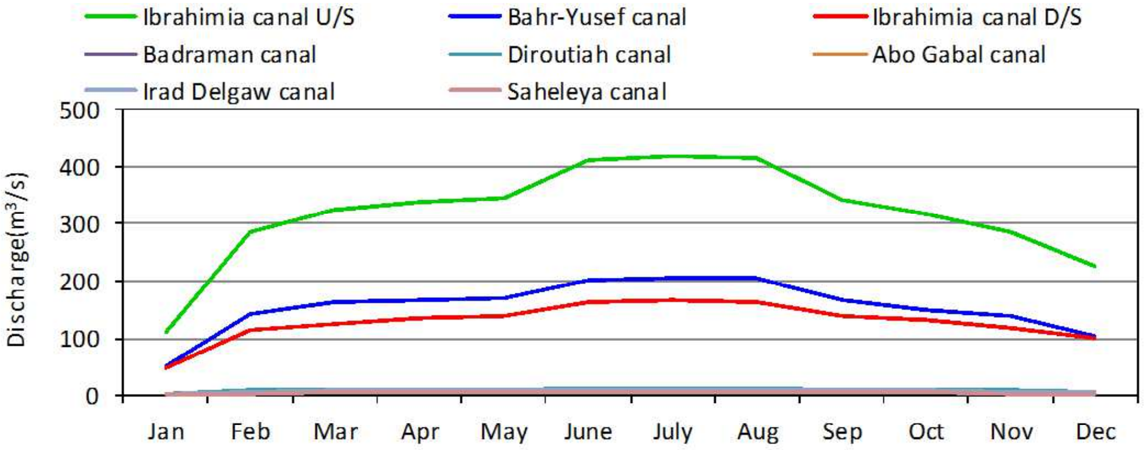


Figure 2-1.15 Calibrated monthly discharge (predicted based on average monthly values from 1999 to 2014)

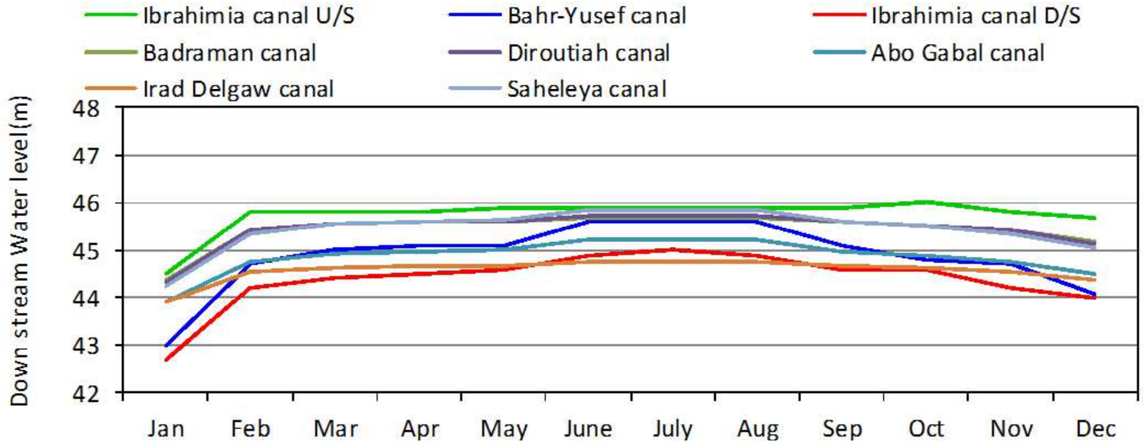


Figure 2-1.16 Calibrated monthly water level (calculated from Table 2-1.9)

iii) Grain size distribution of riverbed material

Out of all the riverbed material study results in the progress report on the physical hydraulic model test conducted by the HRI shown in Table 2-1.11 and Figure 2-1.17, the riverbed material data for the upper reaches of Ibrahimia canal was used. The results of HRI's riverbed material study were reflected in the calculations, and two representative particle diameters shown in Table 2-1.12 were set. The same materials were set for the whole calculated area in this analysis.

Table 2-1.11 Results of riverbed material study

Ibrahimia U/S		Ibrahimia D/S		Bahr-Yusef	
Diameter (mm)	Finer Weight (%)	Diameter (mm)	Finer Weight (%)	Diameter (mm)	Finer Weight (%)
1.4	97.6	1.4	41.1	1.4	97.9
1	97.3	1	41.0	1	97.5
0.85	97.0	0.85	40.9	0.85	97.0
0.5	92.1	0.5	40.6	0.5	89.6
0.355	64.8	0.355	39.3	0.355	70.9
0.212	0.4	0.212	5.4	0.212	1.7
0.15	0.2	0.15	1.8	0.15	0.3
0.075	0.1	0.075	0.2	0.075	0.1
0.063	0.1	0.063	0.1	0.063	0.1
0.01	0.0	0.001	0.0	0.001	0.0

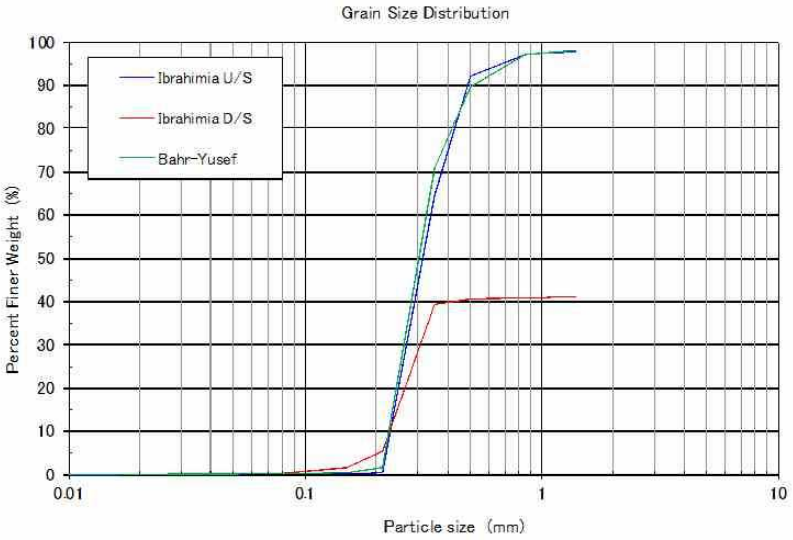


Figure 2-1.17 Grain size distribution of riverbed material

Table 2-1.12 Representative particle diameter and content rate in calculations

Representative particle diameter	Content rate
(mm)	(%)
0.6	34.1
0.25	65.6

iv) Bed load formula

The bed load discharges are computed using the following formula developed by Ashida and Michiue.

For the calculation of q_{bxk} sediment discharge per unit width in the x direction, and q_{byk} sediment discharge per unit width in the y direction, first q_{bk} bed load sediment per unit width is calculated using the Ashida-Michiue formula (2-4).
Next, sediment discharge is distributed in the x and y directions by flow velocity distribution on the bed surface, and q_{bxk} and q_{byk} are obtained.

Ashida-Michiue formula:

$$\frac{q_{bk}}{\sqrt{sgd_k^3}} = 17 p_{bk} \tau_{*ek}^{3/2} \left(1 - \frac{\tau_{*ck}}{\tau_{*k}}\right)\left(1 - \sqrt{\frac{\tau_{*ck}}{\tau_{*k}}}\right) \tag{2-4}$$

v) Suspended load formula

Suspended load is divided into rising flux and falling flux, and each is calculated as shown below using the suspended load formula.

◆Rising flux E_{sk}

Rising flux E_{sk} of D_kth grain is calculated as follows.

$$E_{sk} = W_{sk} C_{ek} \tag{2-5}$$

Where,

W_{sk}: Settling velocity of d_kth grain

C_{ek}: Concentration of D_kth grain at an equilibrium datum plane

C_{ek} Is obtained from the Ashida-Michiue equilibrium datum plane concentration formula as follows:

$$C_{ek} = 0.025 P_{bk} \left[\frac{g(\xi_0)}{\xi_0} - G(\xi_0)\right] \tag{2-6}$$

$$g(\xi_0) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}\xi_0^2\right) \tag{2-7}$$

$$G(\xi_0) = \frac{1}{\sqrt{2\pi}} \int_{\xi_0}^{\infty} \exp\left(-\frac{1}{2}\xi^2\right) d\xi \tag{2-8}$$

$$\xi_0 = \frac{W_{sk}}{0.75 u_*} \tag{2-9}$$

Where,

P_{bk}: Percentage of D_kth grain in the transition layer

u_*: Shear velocity

◆Falling flux D_{sk}

Falling flux D_{sk} of D_kth grain is calculated as follows.

$$D_{sk} = W_{sk} C_{ak} \tag{1-10}$$

Where,

C_{ak}: Sediment concentration of D_kth grain on the riverbed

Sediment concentration C_k of each grain size is obtained from the advection-diffusion equation.

vi) Boundary conditions

The bed load and suspended load are given together with the inflow from the upstream end of Ibrahimia canal.

The amount of sand from the upstream end is given the equilibrium sand feed based on bed slope.

The suspended load according to the flow is given by the C-Q formula shown below. Coefficient α and coefficient β are based on general values in *Hydraulics Formulae 1999* (edited by the Japan Society of Civil Engineers) and highly reproducible values for riverbed variation were set by the calibration calculations.

A= 1.5 × 10^{-7}, β= 2 were set in this analysis.

$$Q_{\sin} = \alpha Q^{\beta} \tag{1-11}$$

Where, Q_{sin}: Inflowing sediment (m^3/s)
Q: Discharge (m^3/s)
α: Coefficient ($4 \times 10^{-8} - 6 \times 10^{-6}$)
β: Coefficient

4) Analysis case

The analysis case is shown in Table 2-1.13. Riverbed variation calibration shows that it is possible to reproduce and evaluate trends in the riverbed variation of existing river channels. This is achieved by taking the riverbed surveyed in January 2016 after sediment removal as the initial riverbed, and reproducing the riverbed surveyed in November 2015 before sediment removal. Figure 2-1.18 shows the contour diagram of riverbed variations before and after sediment removal.

The typical flow for one year is applied to the constructed model and a prediction calculation of current (existing regulators) and planned (after construction of new regulators) riverbed variation is made. Places where there is significant deposition or corrosion around the regulators are identified from the results, and used as reference points for canal improvement projects, including new regulators.

Table 2-1.13 Calculation case (riverbed variation analysis)

Case	Analysis Content	Riverbed	Facilities	Discharge
Riverbed variation calibration	Calibration	Initial: (2) Calibration object: (1)	Existing	11 months
Present state of riverbed variation	Present state	Initial: (2)	Existing	1 year
Riverbed variation planning	Plans	Initial: (2)	Planned overflow	1 year
Remarks	Riverbed conditions (1): Surveyed in Nov. 2015 (before sediment removal) (2): Surveyed in Jan. 2016 (after sediment removal)			

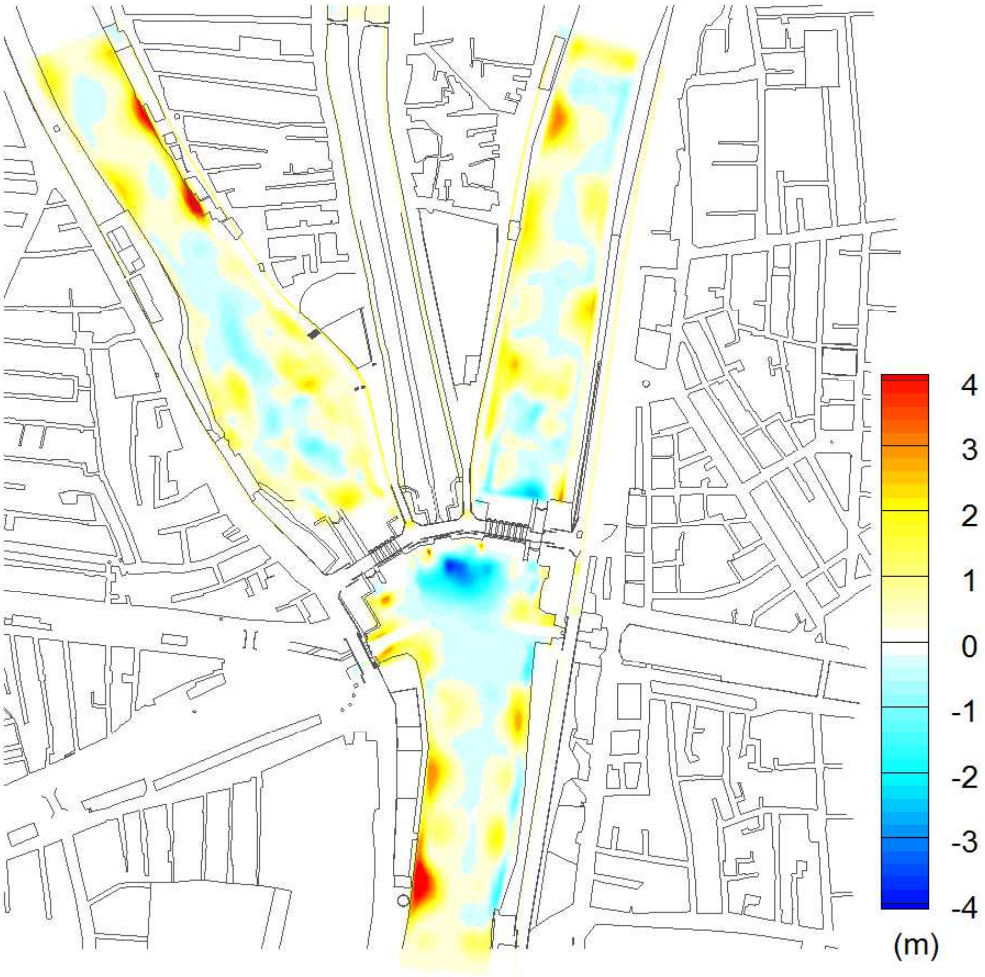


Figure 2-1.18 Change in bed elevation between Nov. 2015 and Jan. 2016

2-2 Evaluation of analysis results

(1) Flow analysis

a) Analysis results

1) Calibration

i) Discharge

Figure 2-2.1 shows the locations of the flow velocity observation points, and Table 2-2.1 and Figure 2-2.2 show flow discharge and cross-sectional average water levels at flow velocity observation points. The calculated flow discharge of the seven canals' regulators can reproduce the actual measured flow quite well.

ii) Average velocity

The average flow velocity at the flow velocity observation point is shown in Table 2-2.2 and Figure 2-2.3. The calculated average flow velocity indicates high reproducibility in all seven canals when compared with the measured average flow velocity.

iii) Cross-sectional velocity

The cross-sectional flow rate results are shown in Figures 2-2.4 to 2-2.10.
According to these, the calculated cross section flow velocity can reproduce the measured cross sectional flow velocity well.

iv) Velocity and vector map

Figure 2-2.11 to 2-2.12 are contour plots showing the flow velocity in color. Figure 2-2.13 is a diagram comparing the downstream of the Bahr Yusef regulator with the physical hydraulic model test, where the vortex on the left side of canal can be seen as the result of the flow analysis.

v) Evaluation

Judging from the calculated velocity and conformity degree of the discharge, the calculated value is found capable of reproducing an actual value.

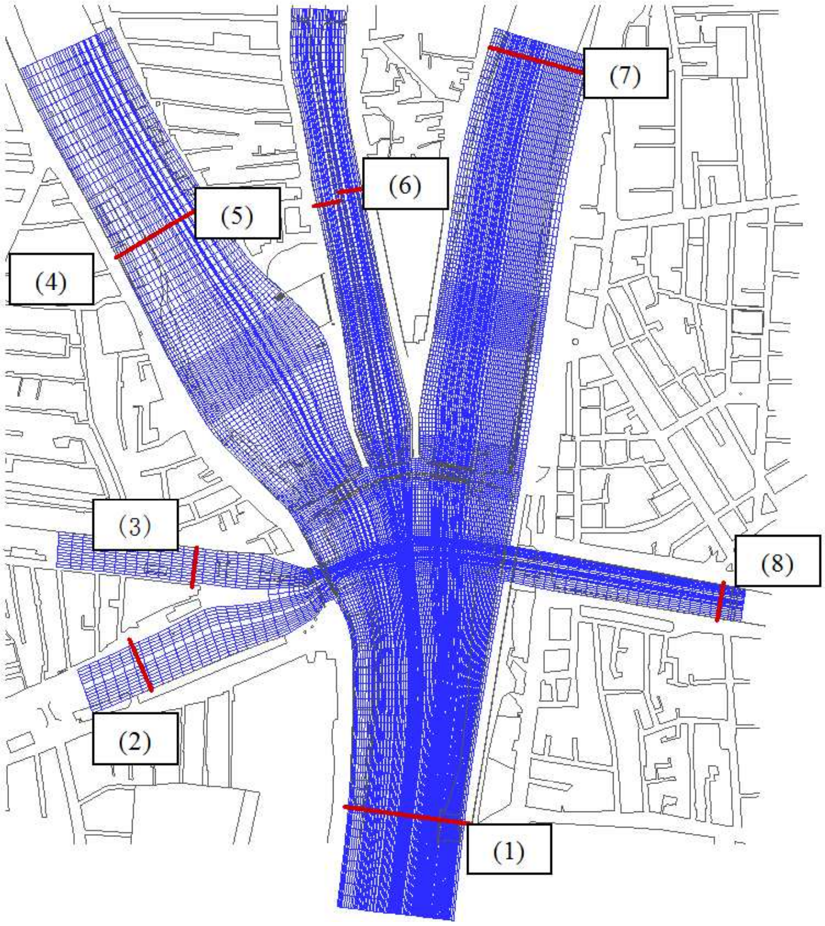


Figure 2-2.1 Locations of flow velocity observation points

Table 2-2.1 Discharge and cross-sectional average water level at the observation points (for verification)

Canal Name	Discharge (m3/s)			Water Level (m)		
	Calculated Value	Measured Value	Difference (Calc-Measure) (%)	Calculated Value	Measured Value	Difference (Calc-Measure) (%)
Ibrahimia canal U/S	355.0	355.0	0.0%	46.1	46.1	0.0%
Irad Delgaw canal	2.1	2.2	-0.4%	44.8	44.8	0.0%
Abo Gabal canal	6.2	6.1	0.6%	45.7	45.7	0.3%
Bahr-Yusef canal	171.5	170.6	0.5%	45.8	45.8	0.0%
Badraman canal	6.1	6.1	0.1%	45.7	45.7	0.0%
Dirutiah canal	9.2	9.2	-0.2%	45.9	45.9	0.0%
Ibrahimia canal D/S	156.8	157.3	-0.3%	45.0	45.0	0.0%
Saheliya canal	3.1	3.1	0.6%	45.7	45.7	0.0%

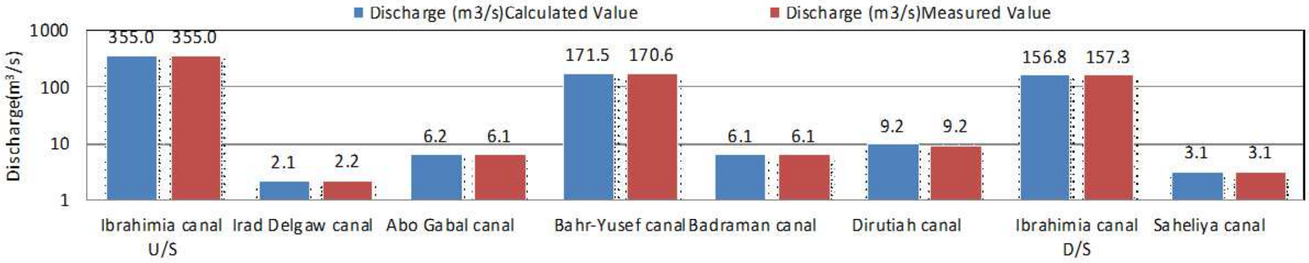


Figure 2-2.2 Discharge comparison graph

Table 2-2.2 Cross-sectional average velocity and correlation coefficient

Canal name	Average Velocity(m/s)	
	Calculated Value	Measured Value
Irad Delgaw canal	0.11	0.12
Abo Gabal canal	0.48	0.47
Badraman canal	0.32	0.32
)Dirutiah canal	0.33	0.33
Saheliya canal	0.25	0.25

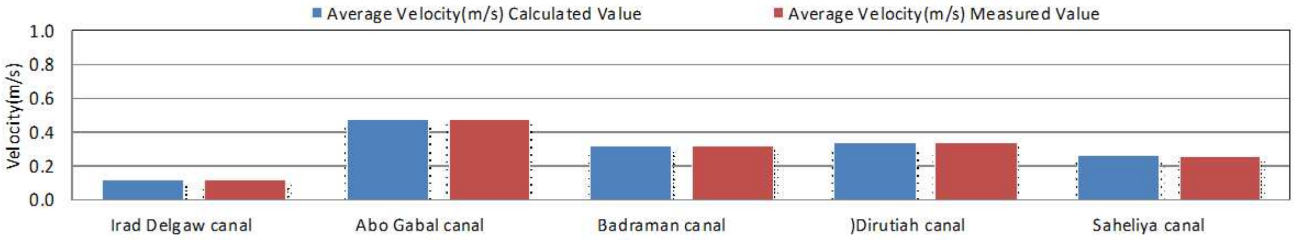


Figure 2-2.3 Average velocity comparison graph

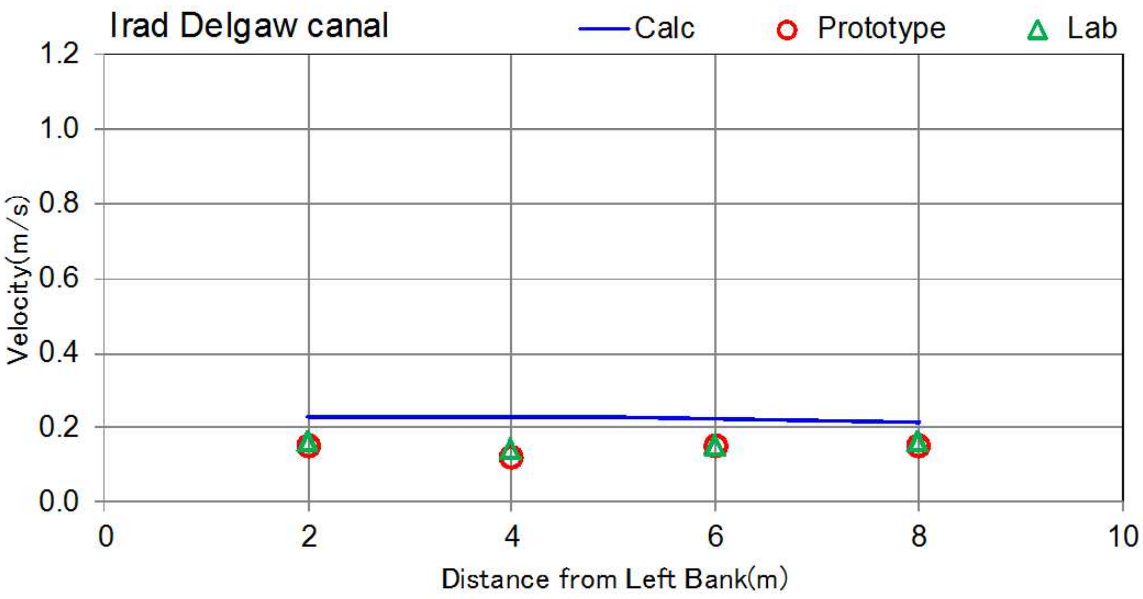


Figure 2-2.4 Comparison of the cross-section velocity in the Irad Delgaw canal

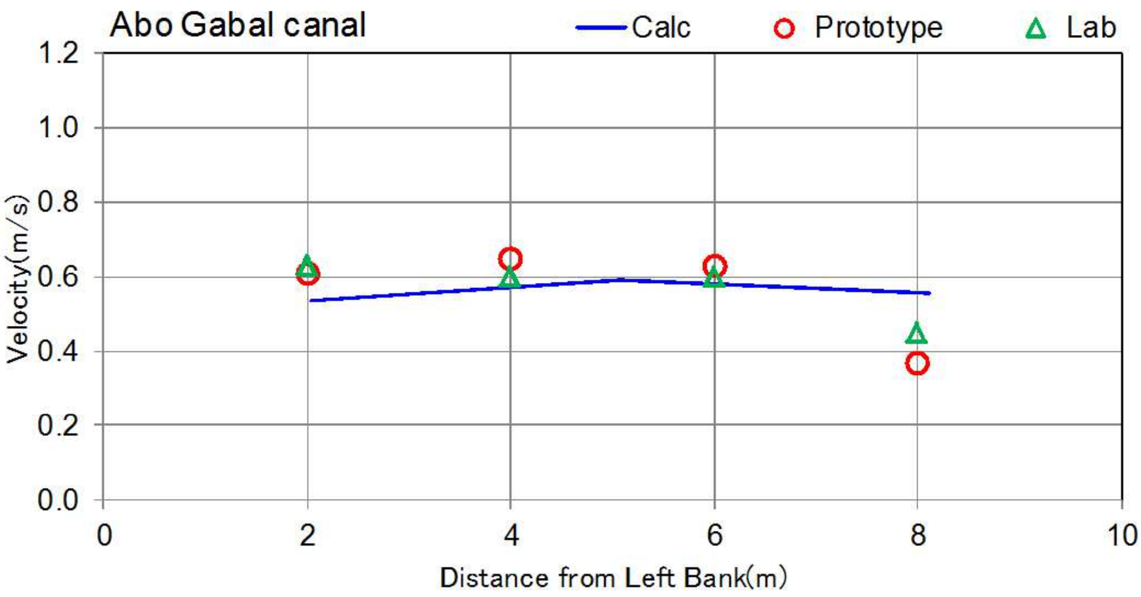


Figure 2-2.5 Comparison of the cross-section velocity in the Abo Gabal canal

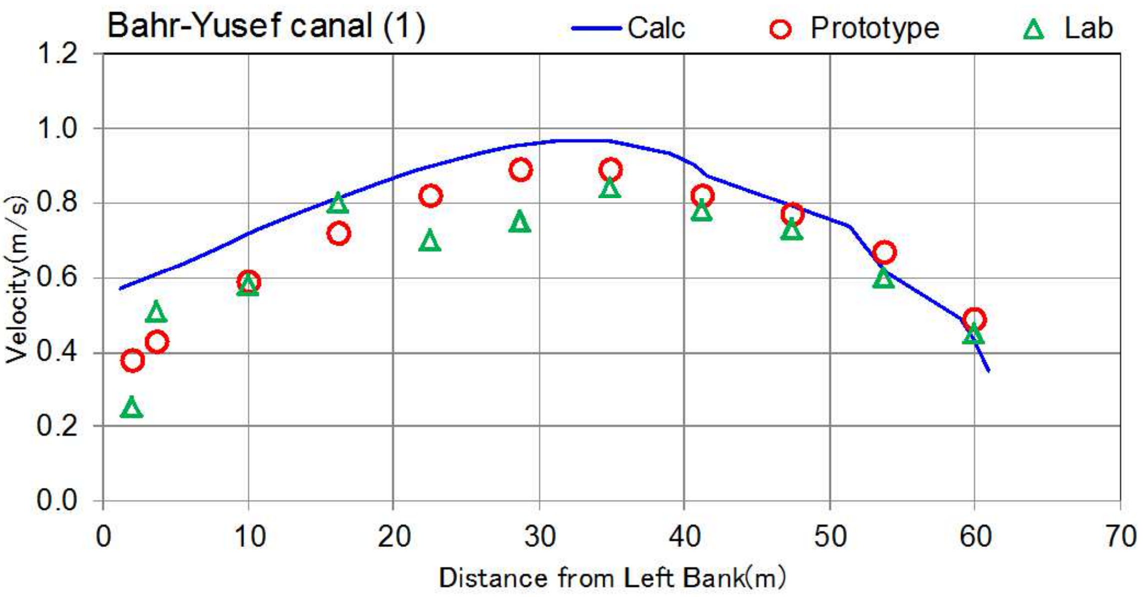


Figure 2-2.6 Comparison of the cross-section velocity in the Bahr Yusef canal

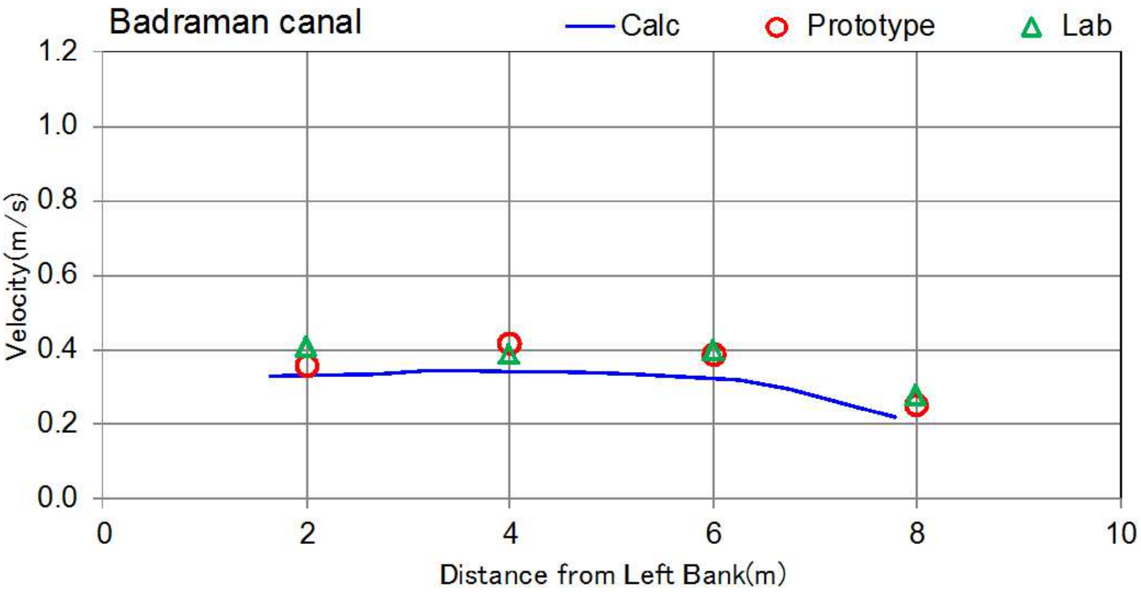
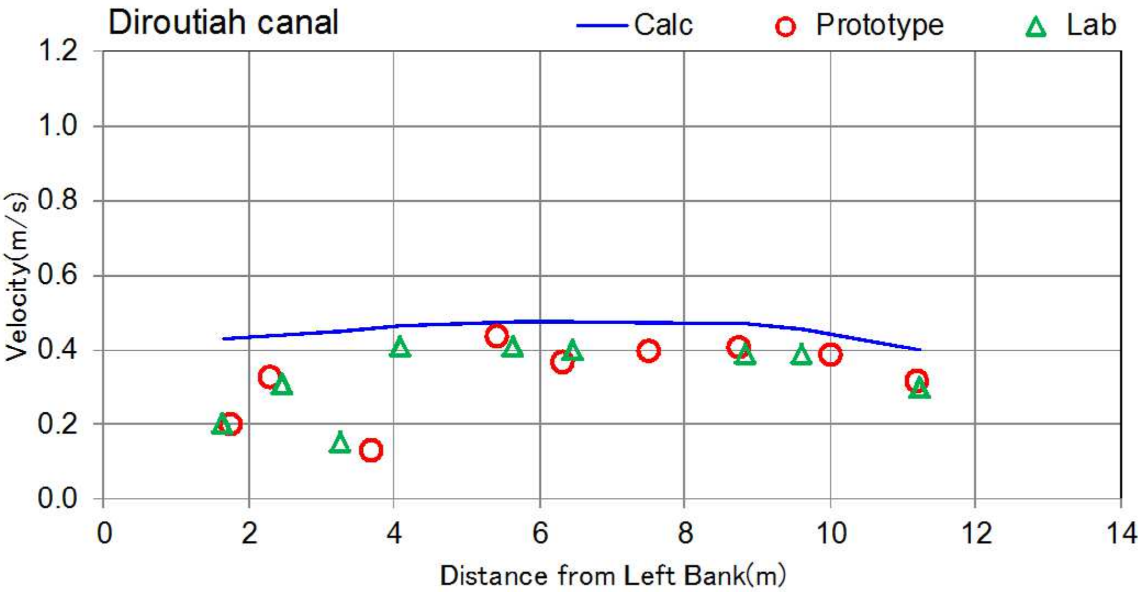


Figure 2-2.7 Comparison of the cross-section velocity in the Badraman canal



Note: Because actual survey velocity of around 3.8m from the left bank did not factor in the shape of the canal, the correlative analysis does not account for this.

Figure 2-2.8 Comparison of the cross-section velocity in the Diroutiah canal

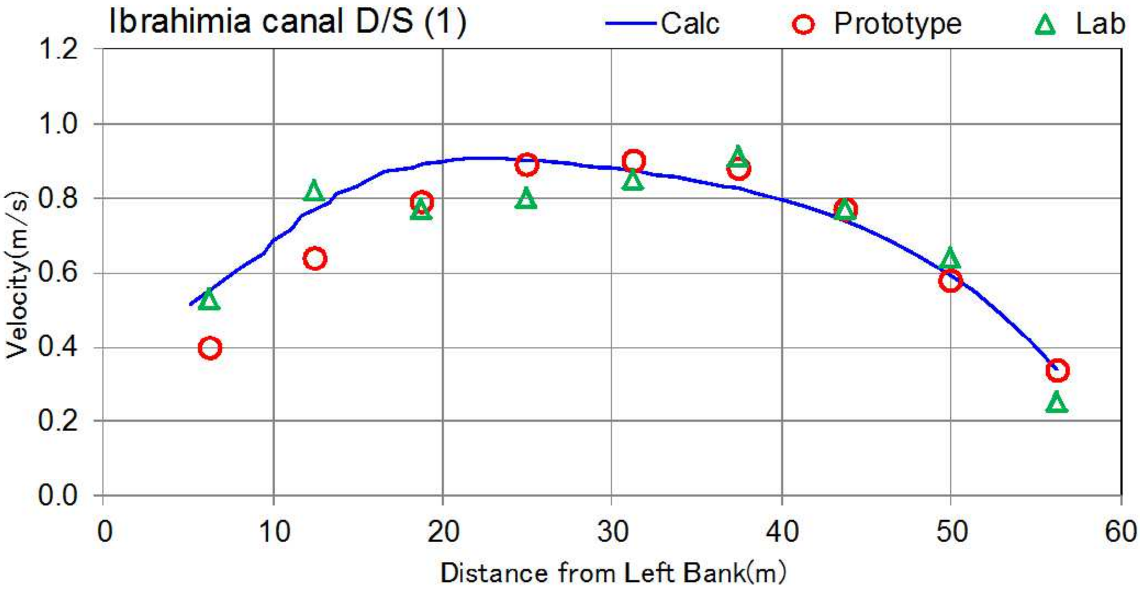


Figure 2-2.9 Comparison of the cross-section velocity in the Ibrahimia canal

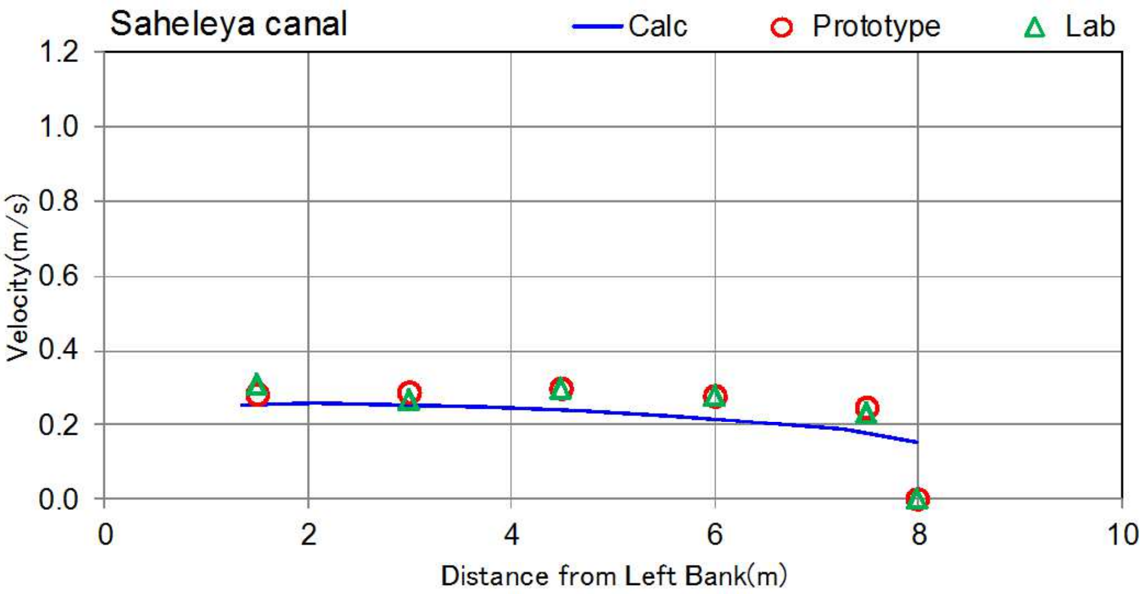
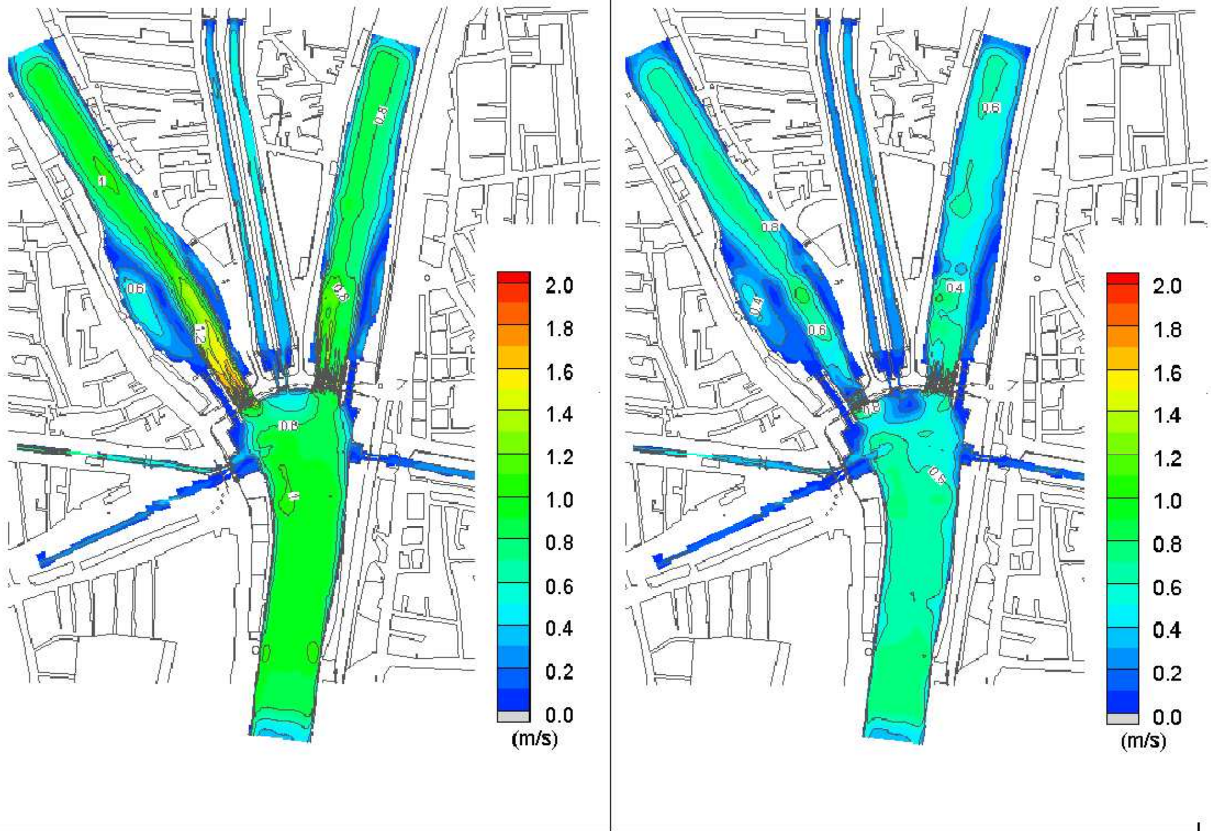
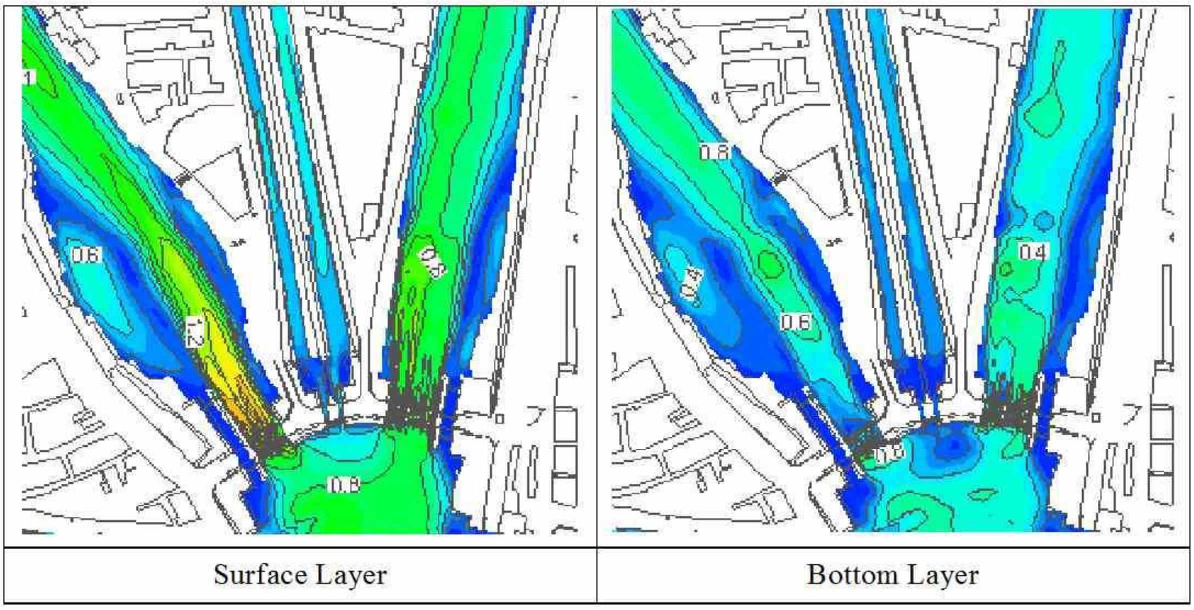


Figure 2-2.10 Comparison of the cross-section velocity in the Sahelyia canal



Surface Layer	Bottom Layer

Figure 2-2.11 Flow velocity contour map (calibration stage)



Surface Layer

Bottom Layer

Figure 2-2.12 Flow velocity contour map
(calibration stage, enlarged view of area around DGRs)

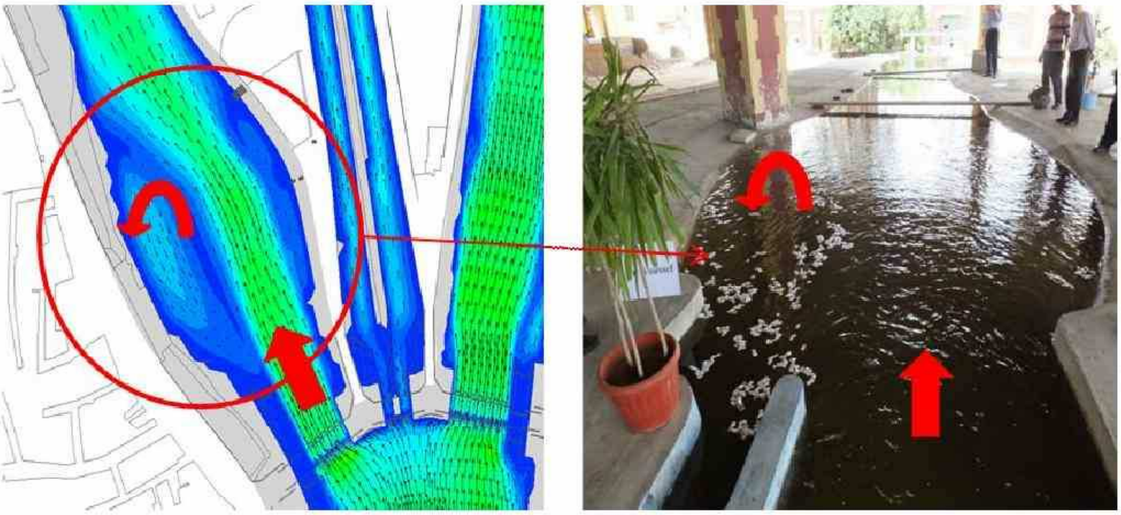


Figure 2-2.13 Comparison between the result of MMA and physical hydraulic model test
(Bahr Yusef canal)

2) Present state

The flow conditions during planned flow distribution were analyzed in the present state.

A comparison of discharge and cross-sectional average water levels at the flow velocity observation points is shown in Table 2-2.3. The discharge comparison is shown in Figure 2-2.14, and the flow velocity contour is shown in Figure 2-2.15 and Figure 2-1.16.

The results showed that an area of slow velocity formed on both banks downstream of the Bahr Yusef regulator, and on the right bank downstream of the Ibrahimia regulator, and that eddies were observed, particularly on the left bank downstream of the Bahr Yusef regulator. It was confirmed that there were no areas surpassing the permission flow velocity (large regulator 2m/s, small regulator 1.5m/s) of the regulator at a regulator spot.

Table 2-2.3 Discharge and cross-sectional average water levels at the observation points (present state)

Canal Name	Discharge(m^3/s)		Water Level(m)	
	Calculated Value	Target Value	Calculated Value	Target Value
Ibrahimia canal U/S	455.0	455.0	46.2	46.3
Irad Delgaw canal	8.2	9.0	45.9	45.9
Abo Gabal canal	6.7	7.0	46.0	45.9
Bahr-Yusef canal	232.9	227.0	45.8	45.8
Badraman canal	11.0	9.0	45.9	45.9
Diroutiah canal	12.2	12.0	45.9	45.9
Ibrahimia canal D/S	186.3	186.0	45.1	45.1
Saheleya canal	5.0	5.0	45.9	45.9

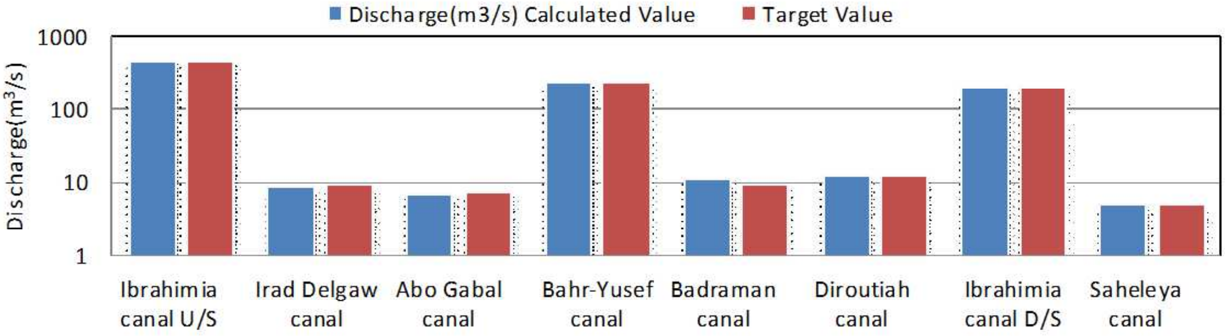
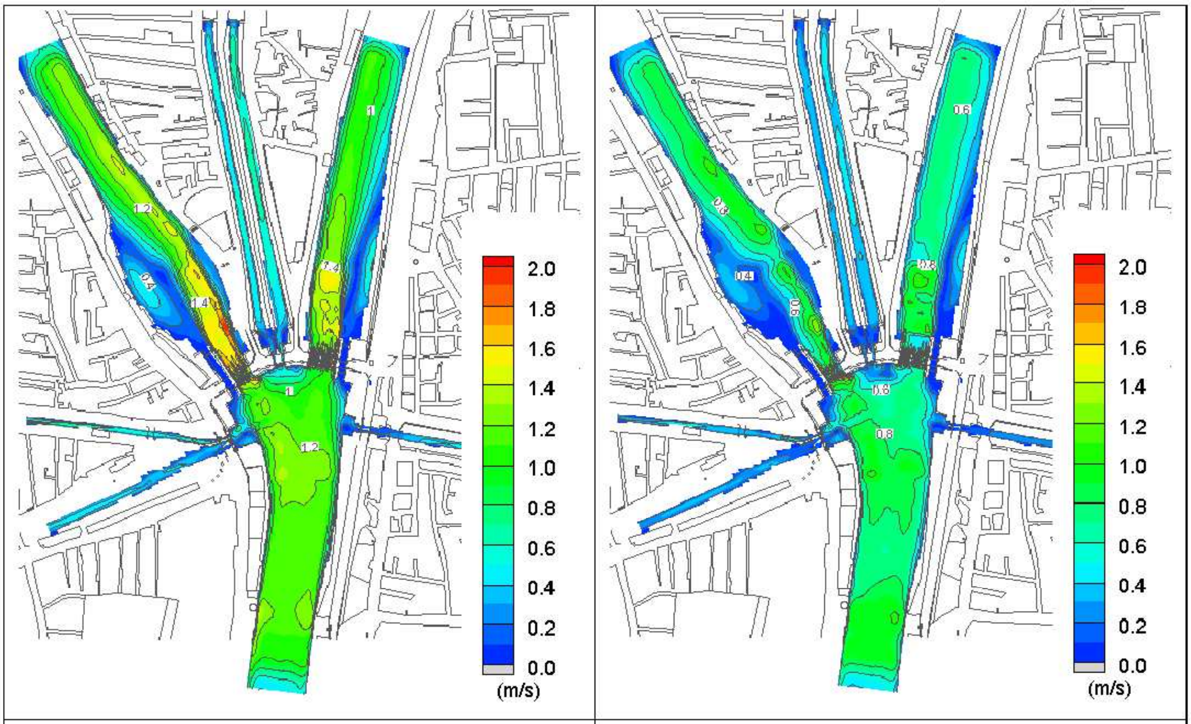
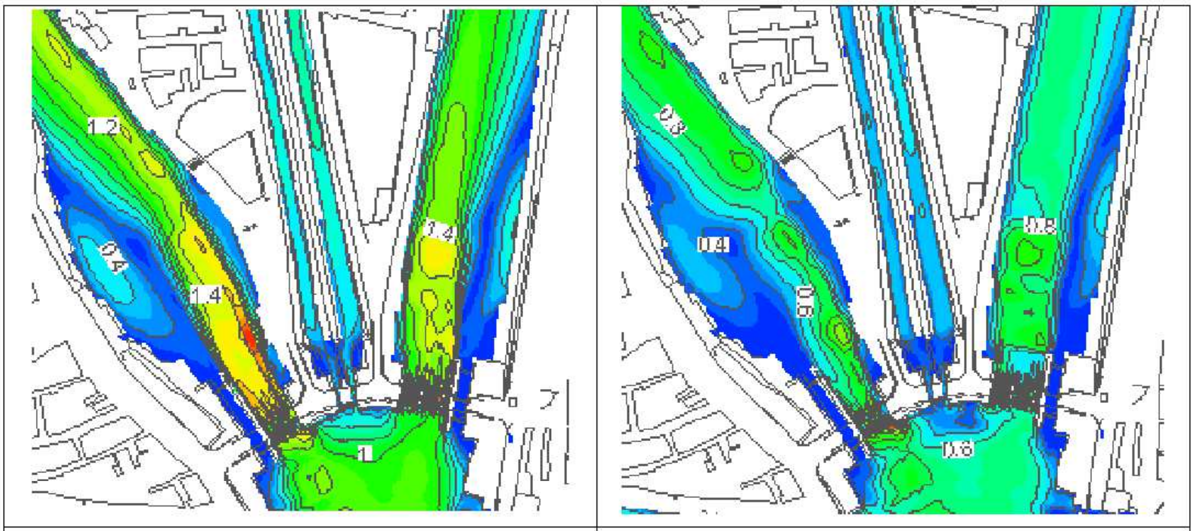


Figure 2-2.14 Discharge comparison graph (present state)



Surface Layer | Bottom Layer

Figure 2-2.15 Flow velocity contour diagrams (present state)



Surface Layer | Bottom Layer

Figure 2-2.16 Flow velocity contour diagrams (present state, enlarged view of vicinity of DGRs)

3) Planning

The flow conditions in design discharge with the underflow and overflow regulator discharge systems were analyzed in the plan.

Table 2-2.4 shows a comparison of the discharge and cross-sectional average water level at the flow velocity observation points. Figure 2-2.17 shows a comparison of the discharge. Figures 2-2.18 to 2-2.21 show the flow velocity contour.

From the results, it was found that areas of slow velocity formed on the left bank downstream of Bahr Yusef regulator and on the right bank both upstream and downstream of Ibrahimia regulator.

There is almost no difference in the flow velocity of the regulator in both overflow and underflow. This may be due to the fact that the depth of the regulator flow is 5m or more. In addition, it was found that the value of the gate on the right side of the flow velocity of the bottom layer of the Ibrahimia regulator had become quite large. This means that the number of gates that regulate the flow ahead of the upstream existing regulator are concentrated on the right bank, and that there is a margin towards the right bank due to the expansion of the downstream of the right bank after it passes through the new bank.

It is understood that no region of the regulator has a flow velocity of 2m/s or more.

Table 2-2.4 Discharge and cross-sectional average water levels at the observation points (planning stage)

Canal Name	Discharge (m^3/s)			Water Level (m)		
	Calculated Value		Target Value	Calculated Value		Target Value
	Underflow	Overflow		Underflow	Overflow	
Ibrahimia canal U/S	455.0	455.0	455.0	46.3	46.3	46.3
Irad Delgaw canal	6.6	5.0	9.0	45.9	45.9	45.9
Abo Gabal canal	8.7	8.2	7.0	46.1	46.0	45.9
Bahr-Yusef canal	230.3	231.5	227.0	45.8	45.8	45.8
Badraman canal	8.9	9.0	9.0	45.9	45.9	45.9
Diroutiah canal	11.8	11.9	12.0	45.9	45.9	45.9
Ibrahimia canal D/S	183.7	184.6	186.0	45.1	45.1	45.1
Saheliya canal	5.0	5.0	5.0	45.9	45.9	45.9

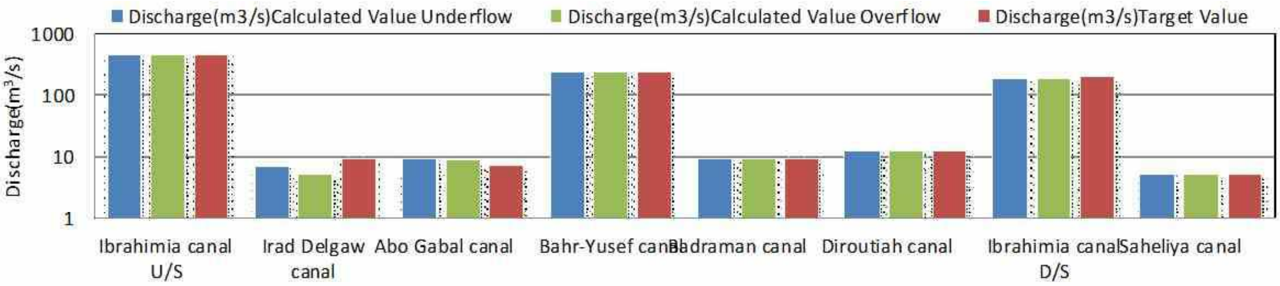


Figure 2-2.17 Discharge comparison graph (planning stage)

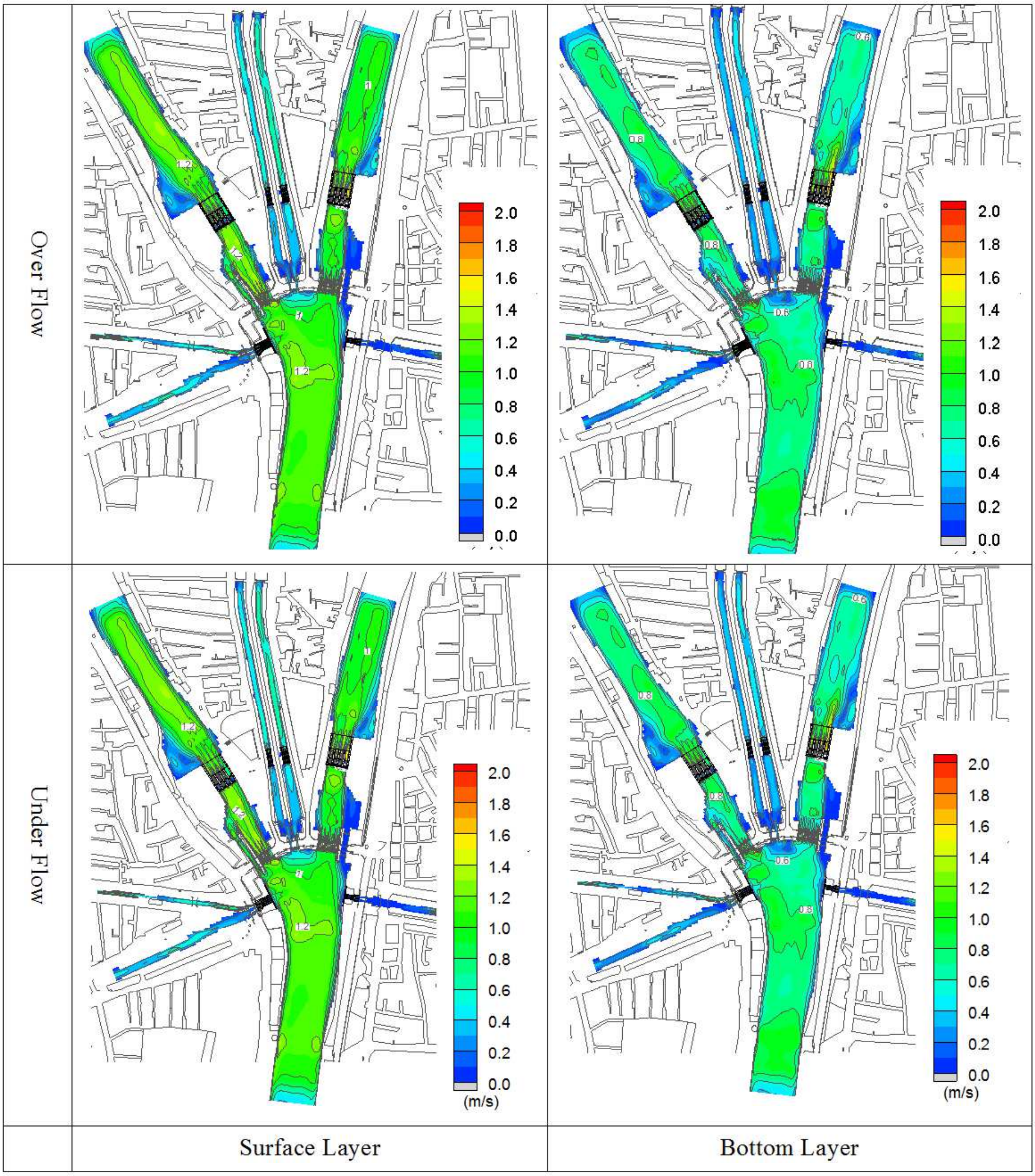


Figure 2-2.18 Flow velocity contour map (planning stage)

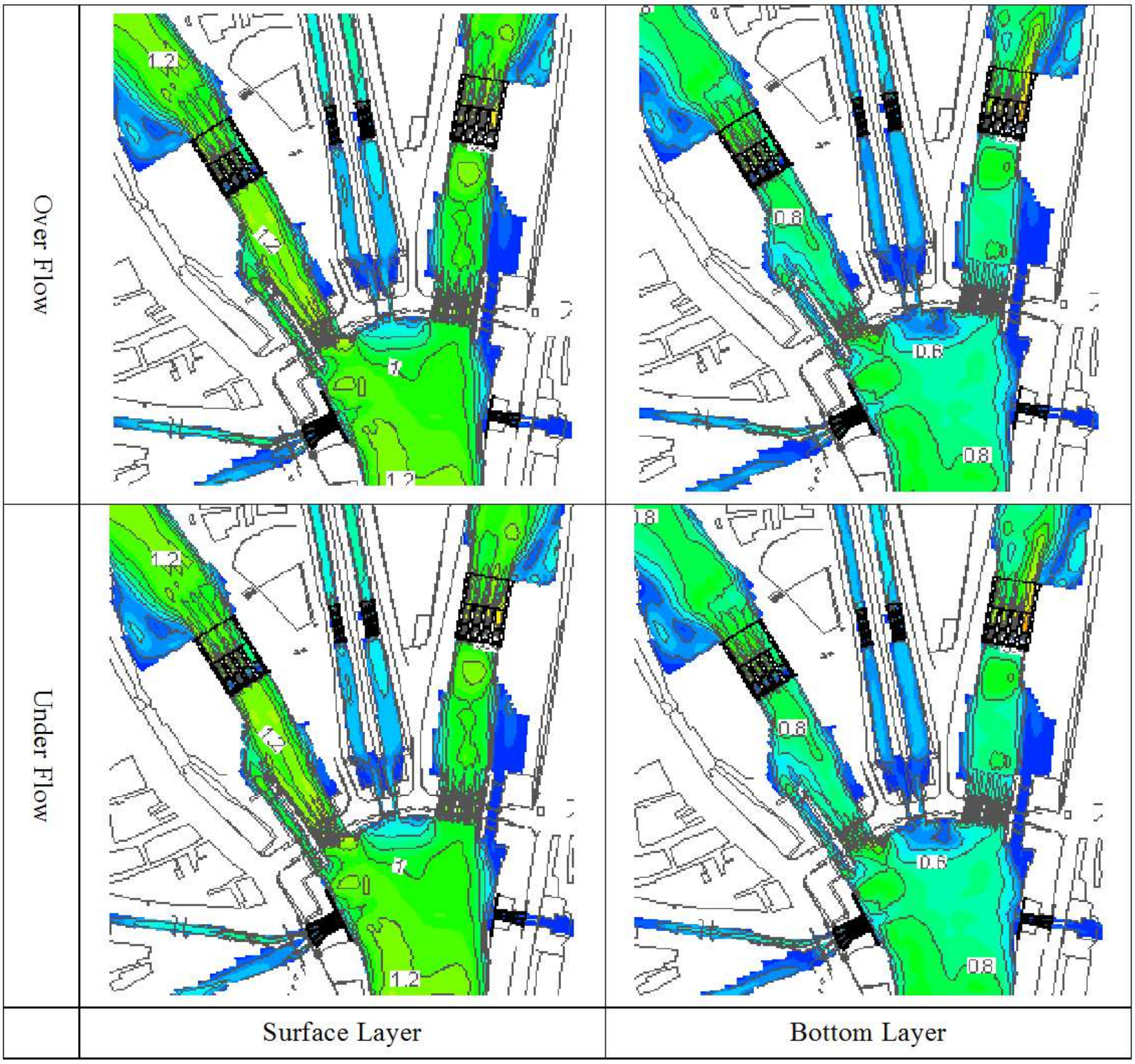


Figure 2-2.19 Flow velocity contour map
(planning stage, enlarged view of vicinity of DGRs)

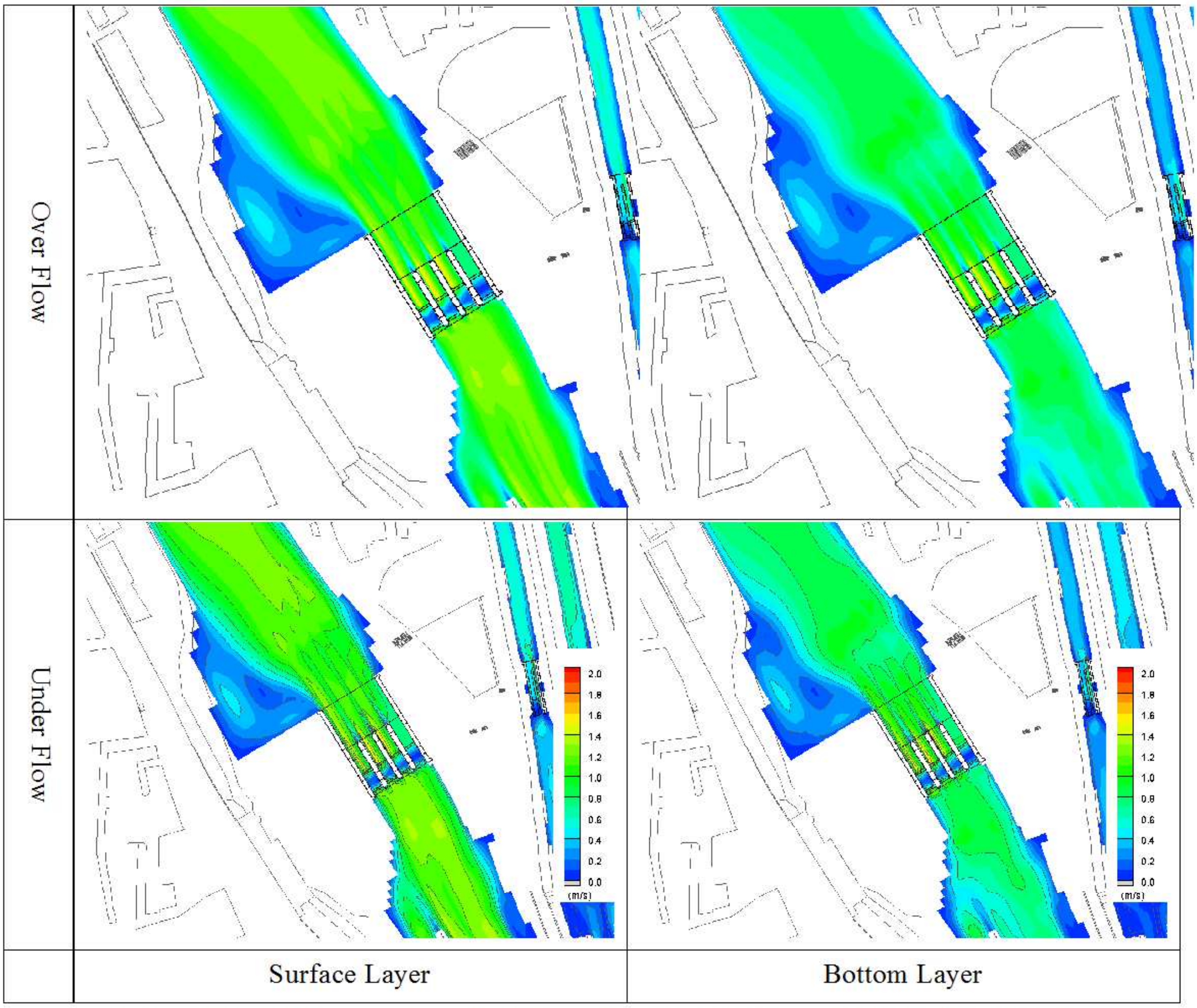


Figure 2-2.20 Flow velocity contour map (planning stage, new Bahr Yusef regulator)

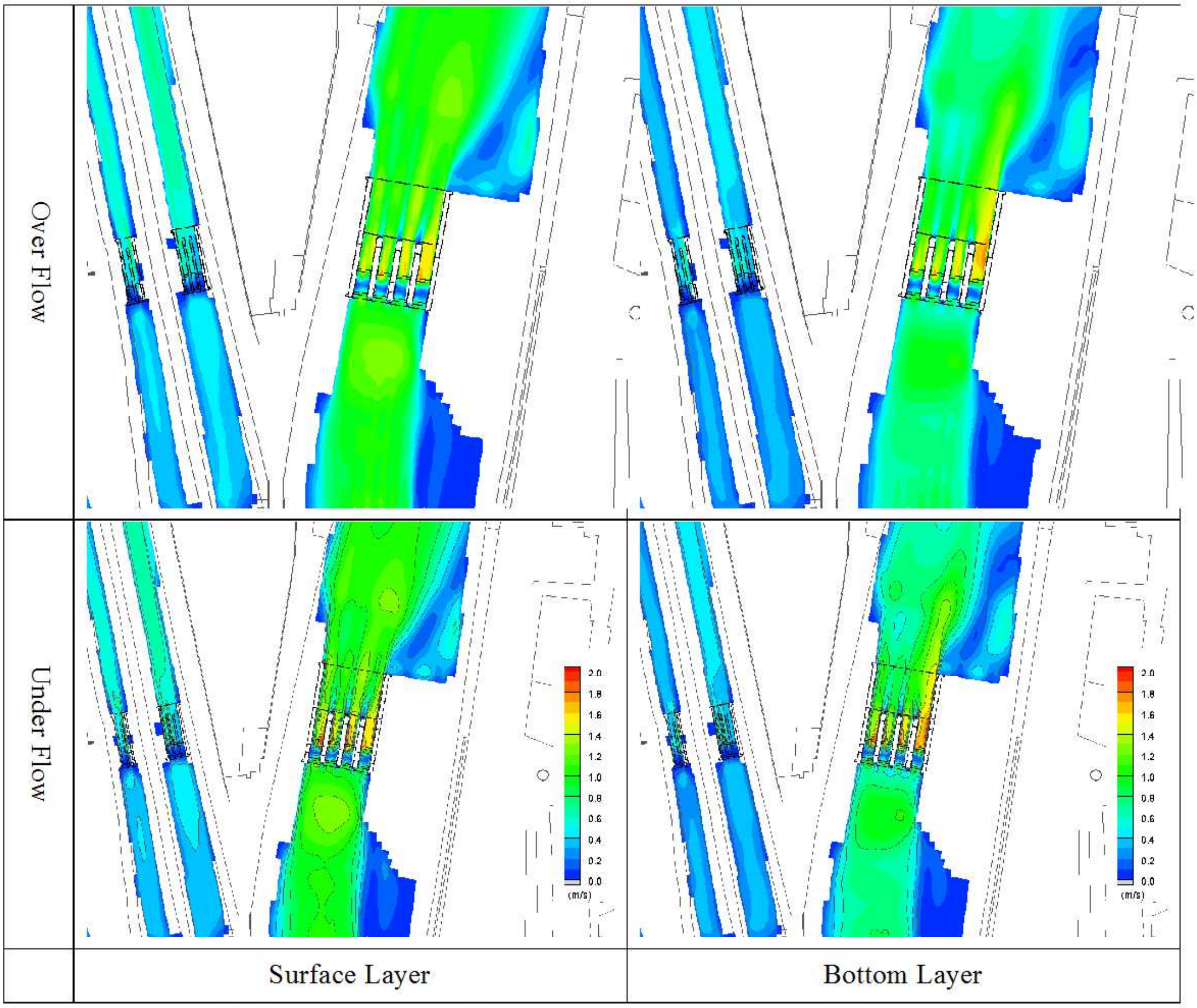


Figure 2-2.21 Flow velocity contour map (planning stage, new Ibrahimia regulator)

b) Evaluation

It was confirmed that the five new regulators could effectively distribute the planned discharge to the seven canals.

In addition, from the analysis result at the design flow, the possibility of scouring was found to be concentrated in the dangerous part where the flow is high velocity, and where the flow velocity of the plan is higher than the present flow.

Figures 2-2.22 to 2-2.25 show the flow velocity difference diagrams obtained by subtracting the present flow velocity from the planned flow velocity. According to these, the clearly marked yellow and red areas show where the flow velocity of the plan is higher than that in the present state. The figures also show that flow velocity in the planning state decreases compared to the present state because the area between DGRs and NDGRs becomes a pool area.

These show that the flow velocity decreases due to the influence of the new regulator.

Regarding the possibility of scouring and danger spots due to high flow velocity; places susceptible to scouring are identified and then evaluated from the results of analysis at design discharge. The evaluation covers places and areas where the planned flow velocity exceeds the present velocity. The construction zones of the new regulators, aprons, etc. are excluded from evaluation.

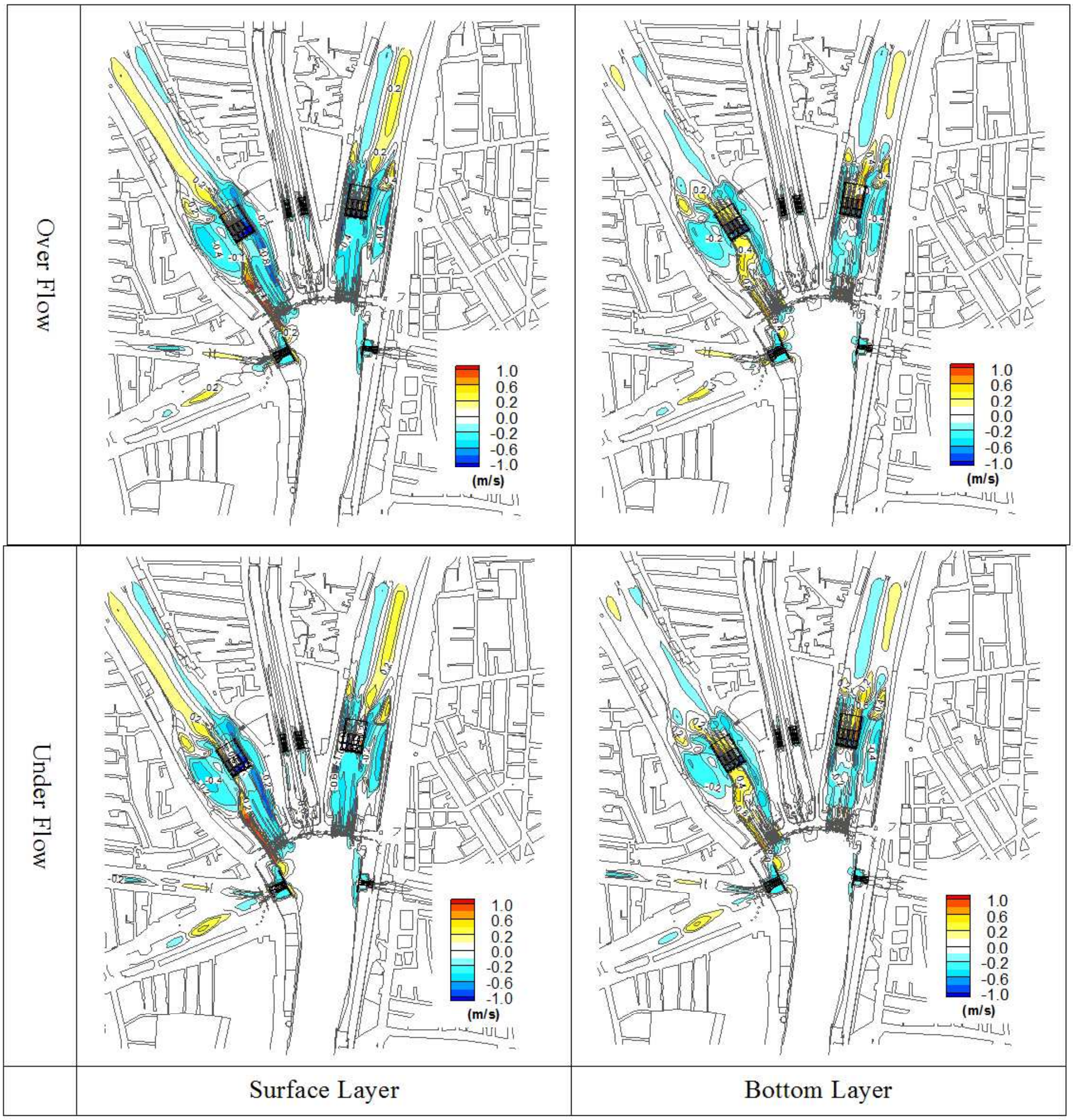


Figure 2-2.22 Difference in flow velocity (planning-present state)

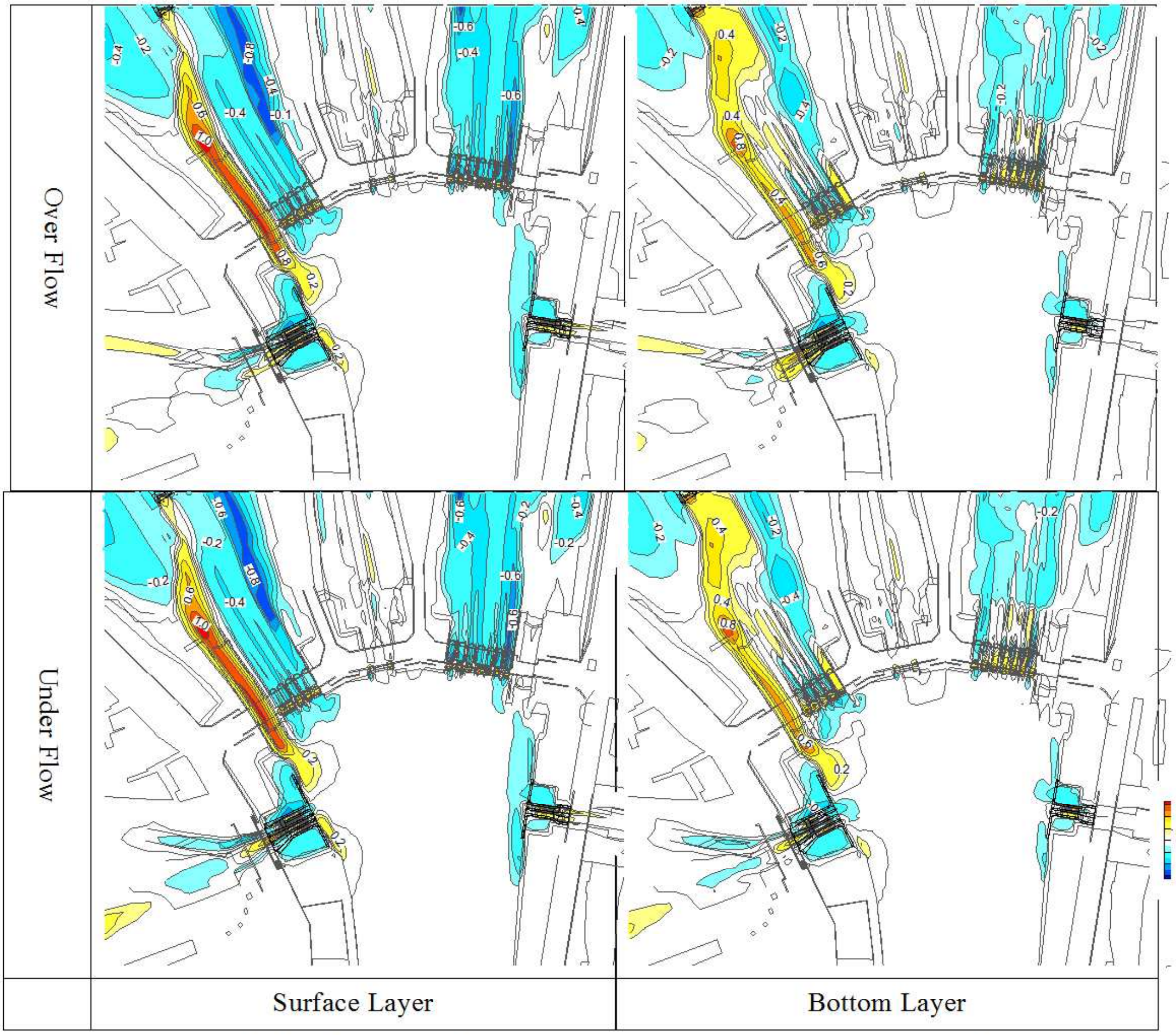


Figure 2-2.23 Difference in flow velocity (planning-present state, around DGRs)

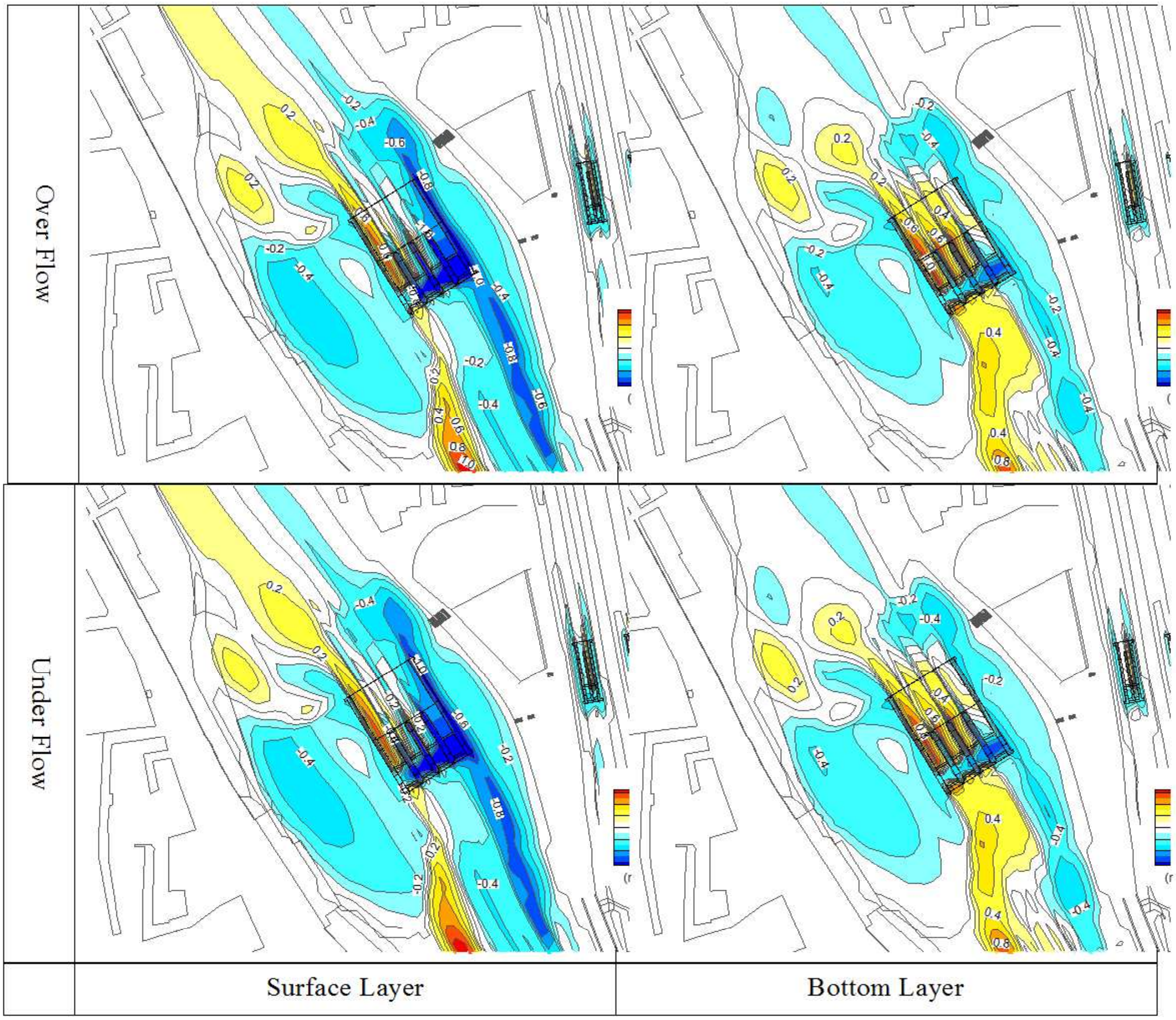


Figure 2-2.24 Difference in flow velocity
(planning-present state, around the new Bahr Yusef regulator)

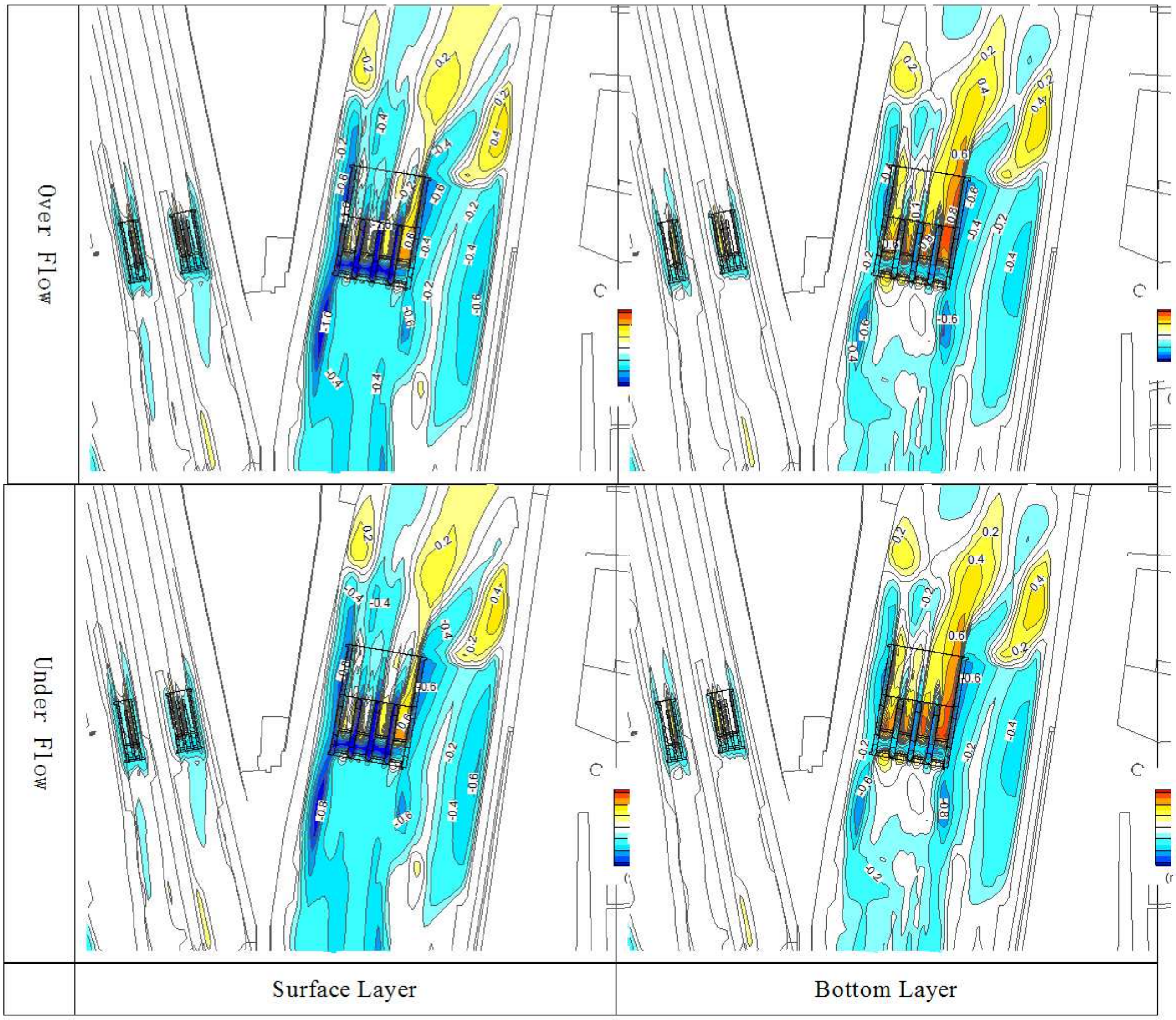


Figure 2-2.25 Difference in flow velocity
(planning – present stage, around the new Ibrahimia regulator)

The results of the present state and planned flow velocity distributions are shown below.

In order to determine the required bed protection, the flow velocity distribution of the riverbed is evaluated.

At the present state, the maximum riverbed flow velocity near the downstream side of the newly built regulator is 0.8m/s to 1.0m/s at the Bahr Yusef canal, and 0.8m/s at the Ibrahimia canal. At the planning stage, it is 1.0m/s at the Bahr Yusef canal, and 0.8m/s to 1.4m/s at the Ibrahimia canal.

At the Ibrahimia regulator in particular, flow velocity is concentrated at the rightmost bank around the four gates. The region with the fast flow velocity extends to the downstream of the apron. The flow velocities of the remaining three canals are within the range of the apron.

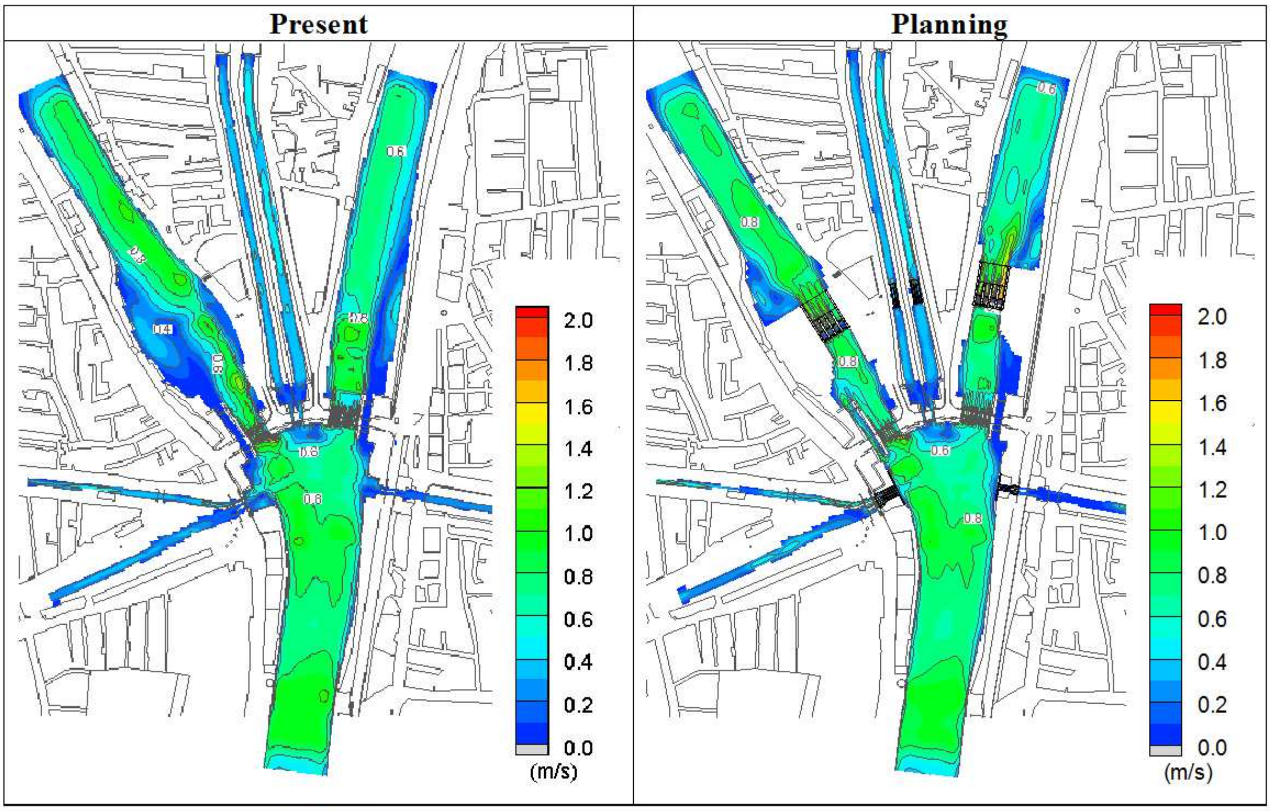
Except for the concentration of local flow velocities in Ibrahimia canal, both Bahr Yusef and Ibrahimia canals show stable flow conditions in the apron after passing through the regulator.

Table2-2.5 Difference in flow velocity at the downstream of new regulators

Item		Bahr Yusef	Ibrahimia
Maximum Velocity (m/s)	Present state	0.8～1.0	0.8
	Plan	1.0	0.8～1.4
	Difference (Present – Plan)	0～0.2	0～0.6
Status of flow		Flow velocity distribution stabilizes around 30m downstream from edge of apron	With the exception of one right bank, low velocity distribution stabilizes around 30m downstream from edge of apron
Range of bed protection		around 30m downstream from edge of apron	around 30m downstream from edge of apron

The countermeasures against the protective bed downstream of the apron due to the concentration of the flow velocity at the right bank side of the new Ibrahimia regulator include:

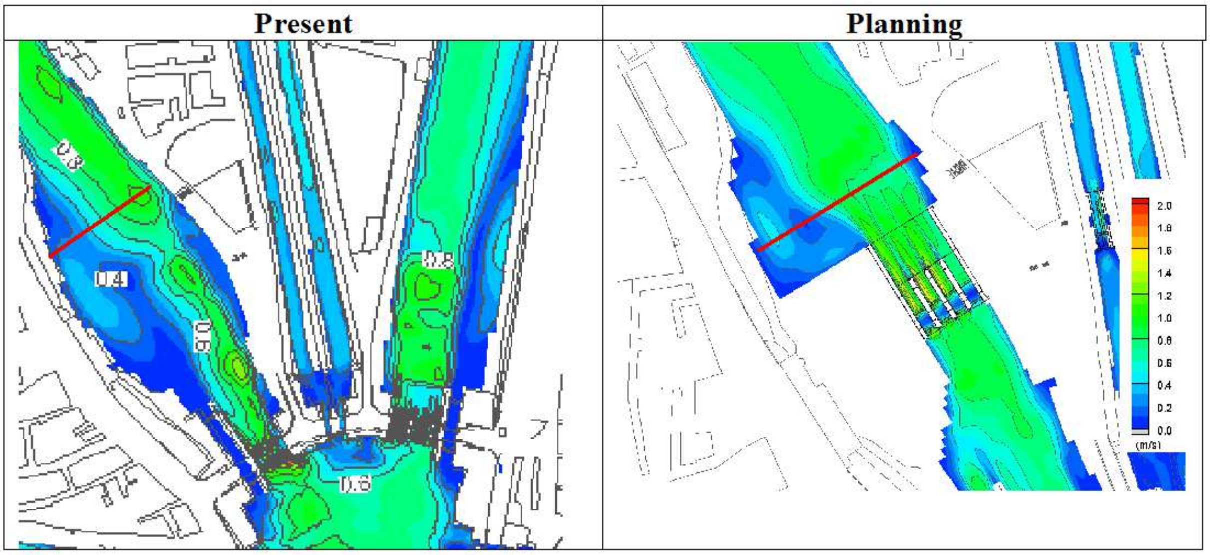
1. In the long term, it is desirable to operate all four vents with equal distribution.
2. A short-term countermeasure would be the installation of stone pitching. However, since this falls outside the realm of temporary works, the installation of stone pitching may be carried out during the winter closure period.



Present

Planning

Figure 2-2.26 Flow velocity on the riverbed (present and planning stage)

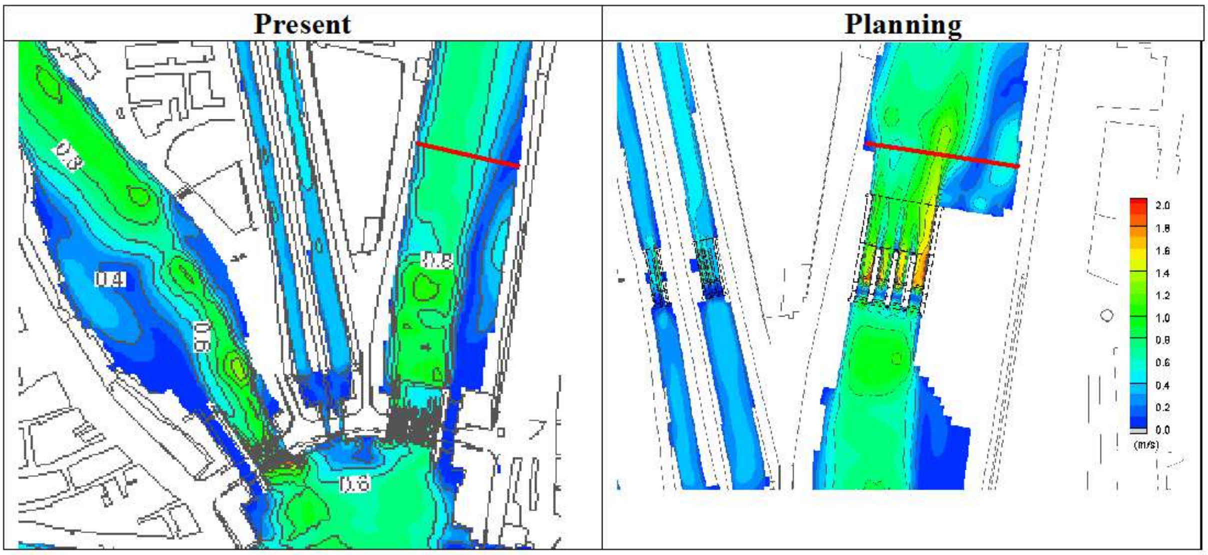


Present

Planning

Note: The red line indicates the point 30m from the downstream end of the apron.

Figure 2-2.27 Flow velocity on the riverbed
(present and planning stage, around the new Bahr Yusef regulator)

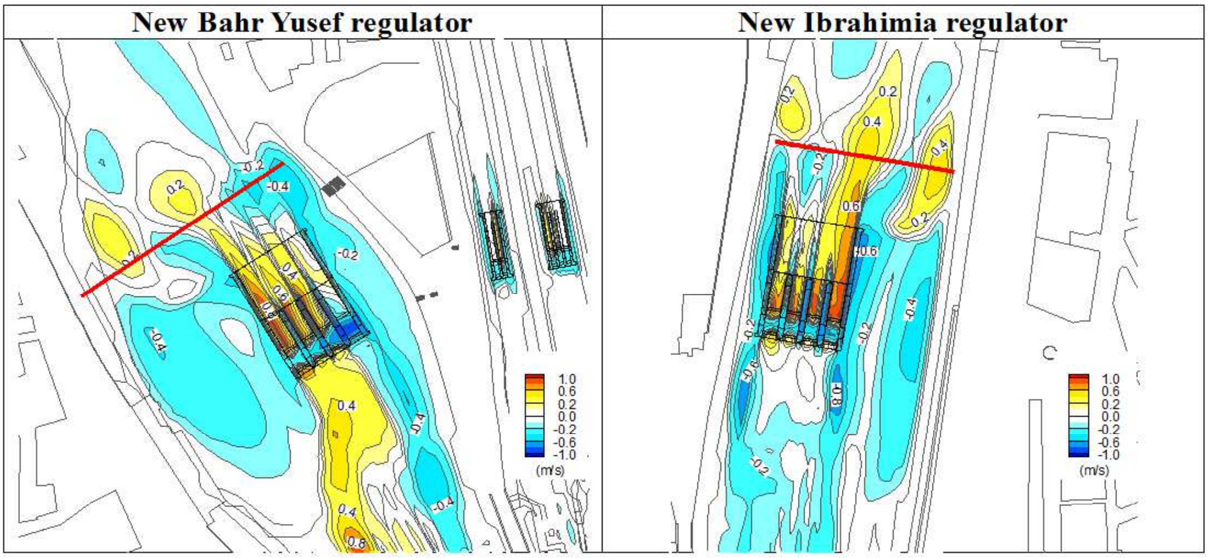


Present

Planning

Note: The red line indicates the point 30m from the downstream end of the apron.

Figure 2-2.28 Flow velocity contour map of riverbed (Ibrahimia regulator)



New Bahr Yusef regulator

New Ibrahimia regulator

Note: The red line indicates the point 30m from the downstream end of the apron.

Figure 2-2.29 Difference in flow velocity of riverbed
(Bahr Yusef and Ibrahimia regulators, present-planning stage)

5) Implementation of plan flow analysis for comparison with physical hydraulic model

The topographic data of January 2016 was utilized in the analysis of the present and planning stage to confirm the influence on the regulator design. On the other hand, the topographic data of August 2015 was utilized in the physical hydraulic model test conducted by HRI.

In the beginning, it was enough to grasp only the tentative results of the mathematical model analysis and the physical hydraulic model test. However, applying the same topographic data was required after the TAC decision in order to make a more detailed comparison. To this end, another case study was conducted with topographic data from Aug. 2016 instead of Jan. 2016.

The results are shown below.

i) Conditions of analysis

In order to compare the results of both models, the following conditions were applied to the mathematical model analysis.

The object of analysis for the comparison is the planned new DGR.

Table 2-2.6 Analysis condition for the comparison with PHMT

Analysis Condition	As of Basic Design Report (BDR)	Analysis for comparison
1.Topography survey data	January 2016	August 2015
2.Computation mesh	The total number of meshes: 198,380	Same as BDR
3.Boundary condition	Upstream canal of the existing NGRs : Discharge End of each canal : Water level	Same as BDR
4.Water level and discharge	Planning stage (NDGRs)	Same as BDR

1. Topographic conditions: topographic data from August 2015 is applied to match the conditions of the physical hydraulic model test (Figures 2-2.31 and 2-2.32).
2. Computation mesh: The computation mesh is the same as the one in the Basic Design Report (Figure 2-2.30).

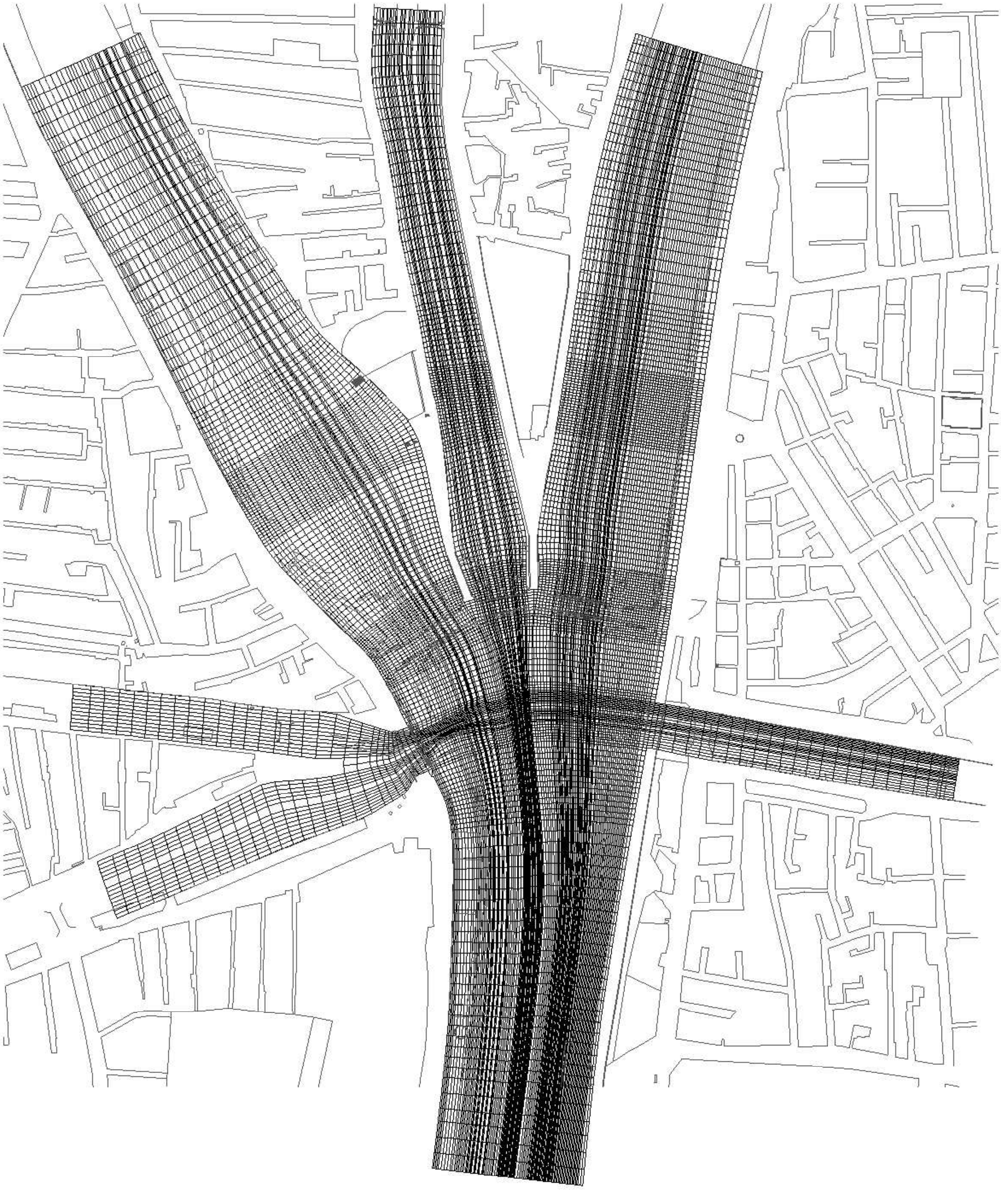


Figure 2-2.30 Computation mesh for canal (comparison with PHMT)

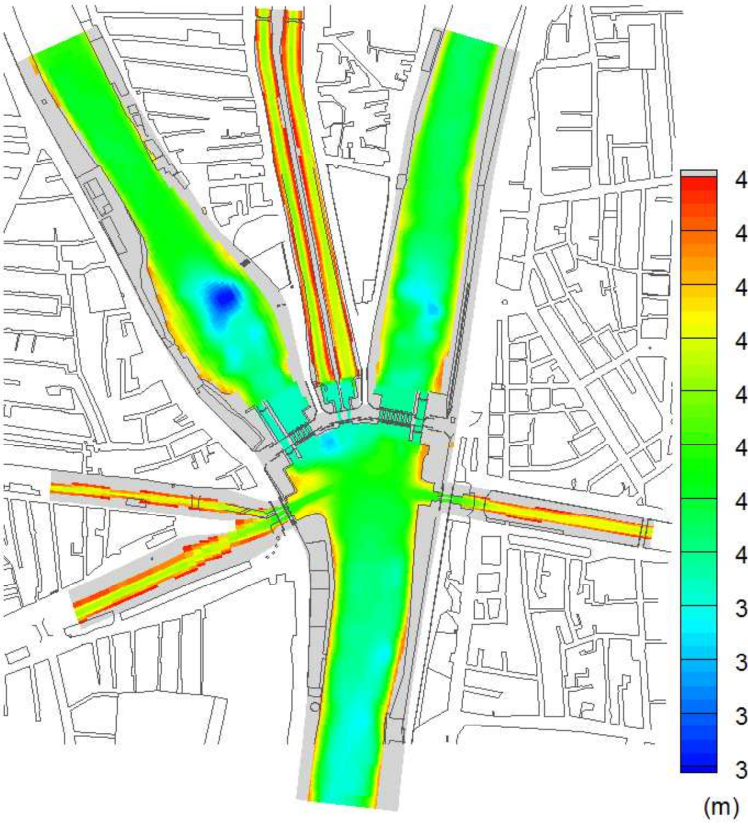


Figure 2-2.31 Topographic contour map based on the surveyed data in August 2015 (calibration and present state)

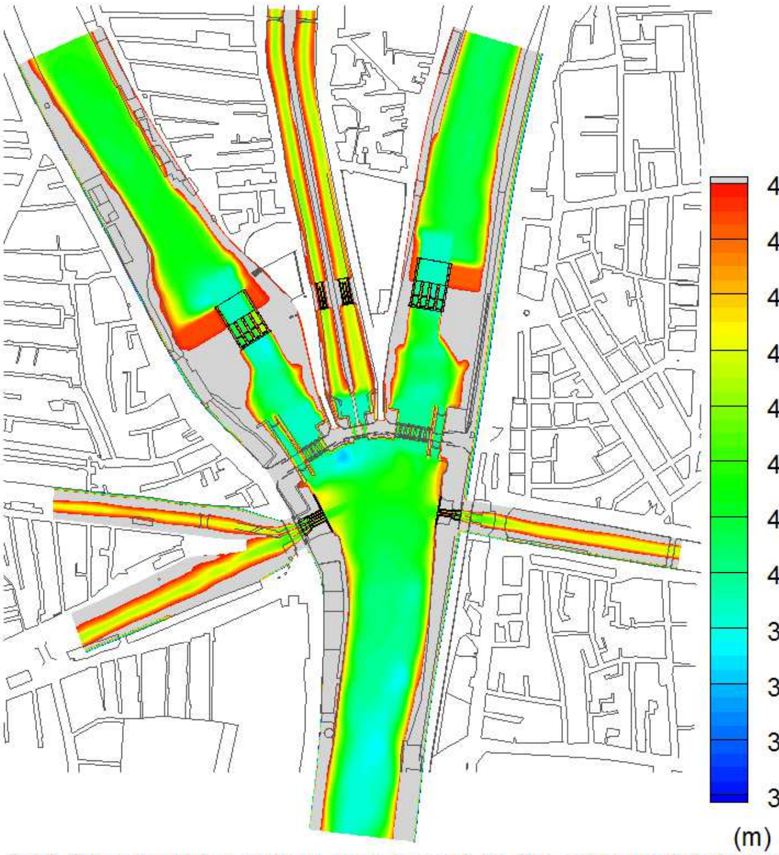


Figure 2-2.32 Topographic contour map based on the surveyed data in August 2015 (planning stage)

- Boundary conditions

The boundary conditions are as followings:

- ✓ Discharge boundary: at the upstream of the existing DGRs
- ✓ Water level boundary: at the end of each canal

- Water level, inflow to NDGRs, and outflow from each NDGR

The water level boundary is adjusted according to the data provided by the Water Distribution Sector shown in Table 2-2.7 (the same boundary is applied in the design of the NDGRs). The discharge boundary is given as 455m^3/s at the upstream end.

Table 2-2.7 Analysis condition of water level, inflow and outflow

Item	US. of Regulators	DS. of regulators							Remarks
	existing DGRs	Bahr Yusef	Ibrahimia	Badraman	Diroutiah	Abo Gabal	Irad Delgaw	Sahelyia	
Water Level(m)	46.30	45.82	45.13	45.90	45.90	45.90	45.90	45.90	Target Value
Inflow (m^3/s)	455	—	—	—	—	—	—	—	Up stream
Outflow of regulator (m^3/s)	—	27	186	9	12	7	9	5	Target Value

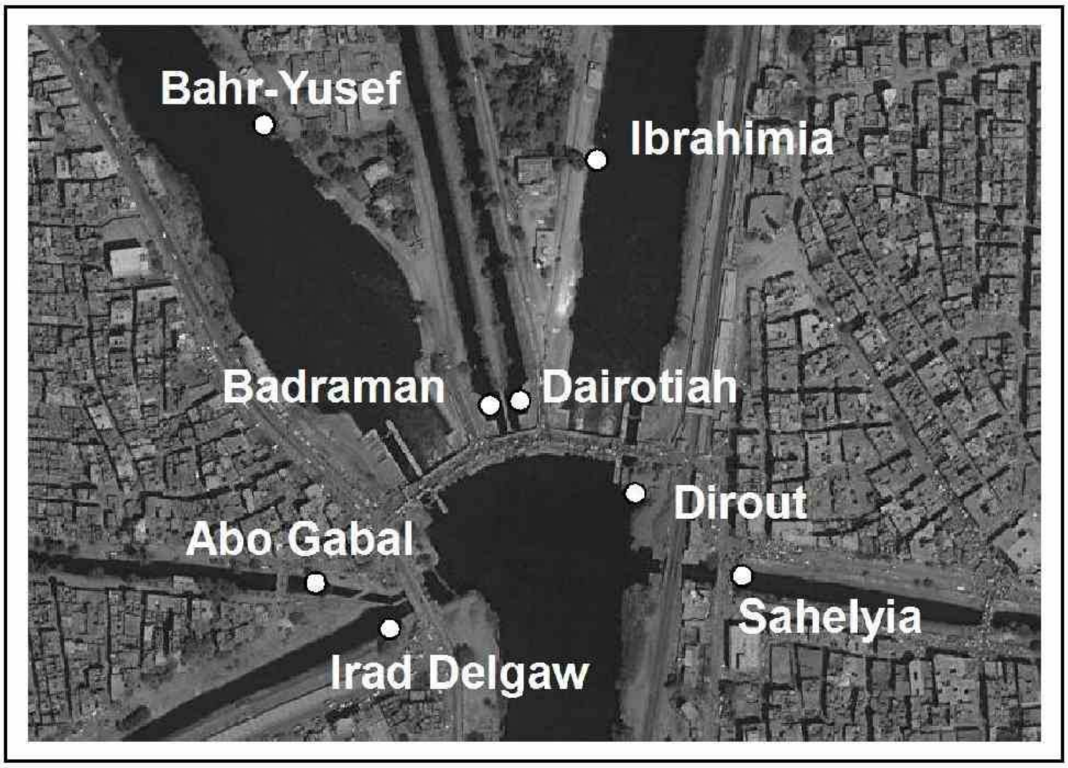


Figure 2-2.33 Measuring point of water level

ii) Results and evaluation of analysis

Figure 2-2.34 shows the location of the observation sections, and Table 2-2.8 and Figure 2-2.35 both show the comparison between the observed water level and discharge volume, and the calculated water level and discharge volume at each section.

Firstly, the results in the figures and the table show similar average discharge and water levels, which indicate that the calculations under the conditions above are good enough to show the flow state at the planning stage.

Figure 2-2.36 and Figure 2-2.37 show the velocity distribution map of the surface layer and the bottom layer in the planning stage. Figure 2-2.38 and Figure 2-2.39 show the enlarged map of Figure 2-2.36 around the two new large regulators.

Secondly, the results above, show the stagnation area in the downstream of the new regulators as recorded in the physical hydraulic model: on the left bank of the Bahr Yusef canal, and the right bank of the Ibrahimia canal. According to Figure 2-2.39, the bottom flow velocity at the first vent from the right side is faster than that at the other new Ibrahimia vents, which also corresponds to the physical hydraulic model test results.

Figure 2-2.40 shows the water level distribution map at the planning stage. Figure 2-2.42 and Figure 2-2.43 show the cross-sectional velocity distribution at each cross-section: 30m, 50m, and 100m downstream from the new regulators as located and marked in Figure 2-2.41.

Results from those figures indicate the followings;

- The flow velocity distribution at 30m and 50m downstream of each regulator effectively reproduce the effect of piers, showing the lower velocities with regular distance (Figure 2-2.42, and 2-2.43).
- The velocity at the 30m downstream from the new regulators is at most 1.2m/s on average, showing lower velocity further downstream.

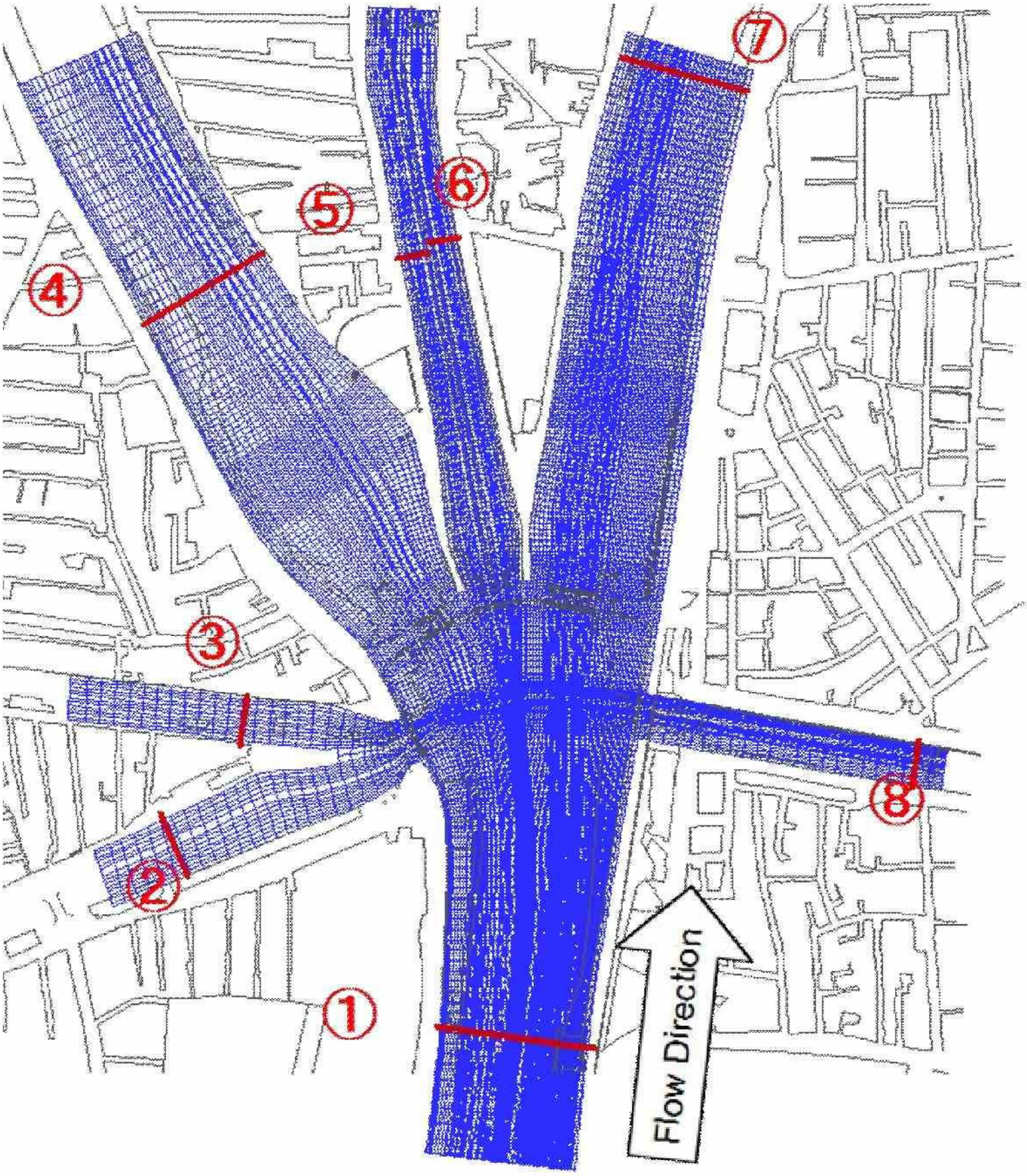


Figure 2-2.34 Observation sections

Table 2-2.8 Comparison between the calculation results (calc) and observed results (target) of the discharge volume and the average water level at the observation sections

Canal name	Discharge			Water level		
	Calc	Target	Difference	Calc	Target	Difference
Ibrahimia canal U/S	455.0	455.0	0.0%	46.3	46.3	-0.1%
Irad Delgaw canal	9.0	9.0	-0.3%	45.8	45.9	-0.2%
Abo Gabal canal	7.1	7.0	1.5%	46.0	45.9	0.2%
Bahr Yusef canal (1)	228.7	227.0	0.7%	45.8	45.8	0.0%
Badraman canal	8.9	9.0	-0.7%	45.9	45.9	0.0%
Dairutiah canal	11.9	12.0	-0.7%	45.9	45.9	0.0%
Ibrahimia canal D/S (	184.4	186.0	-0.8%	45.1	45.1	0.0%
Sahelyia canal	5.0	5.0	-0.7%	45.9	45.9	0.0%
		(m³/s)	(%)		(m)	(%)

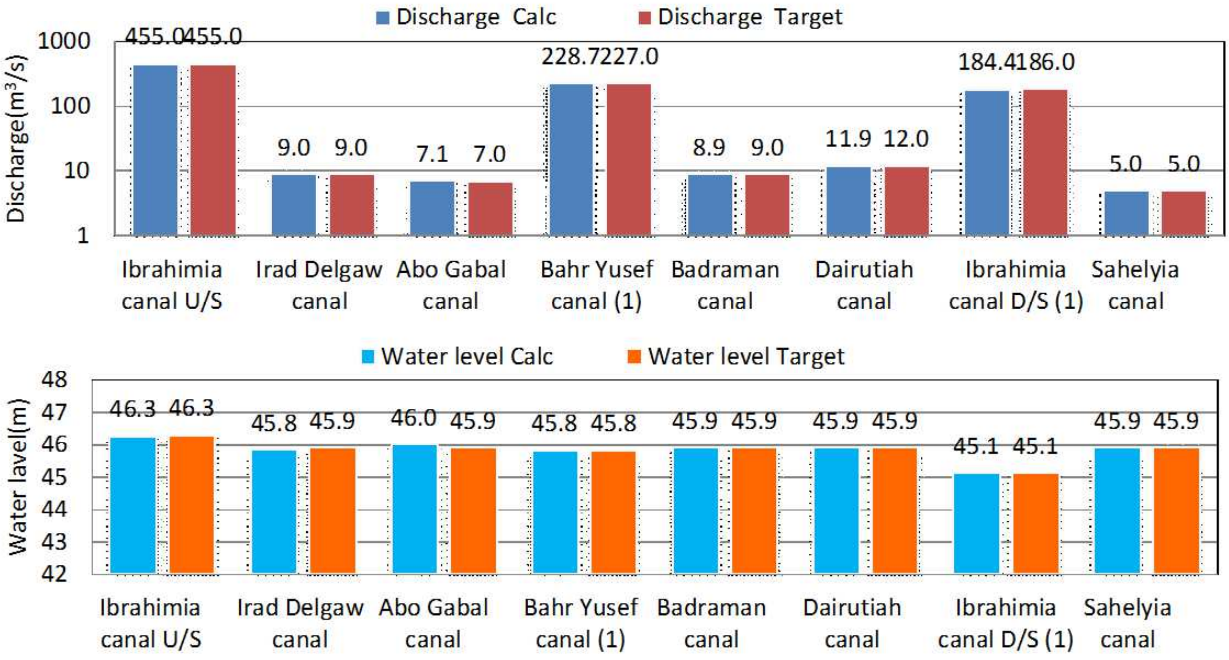
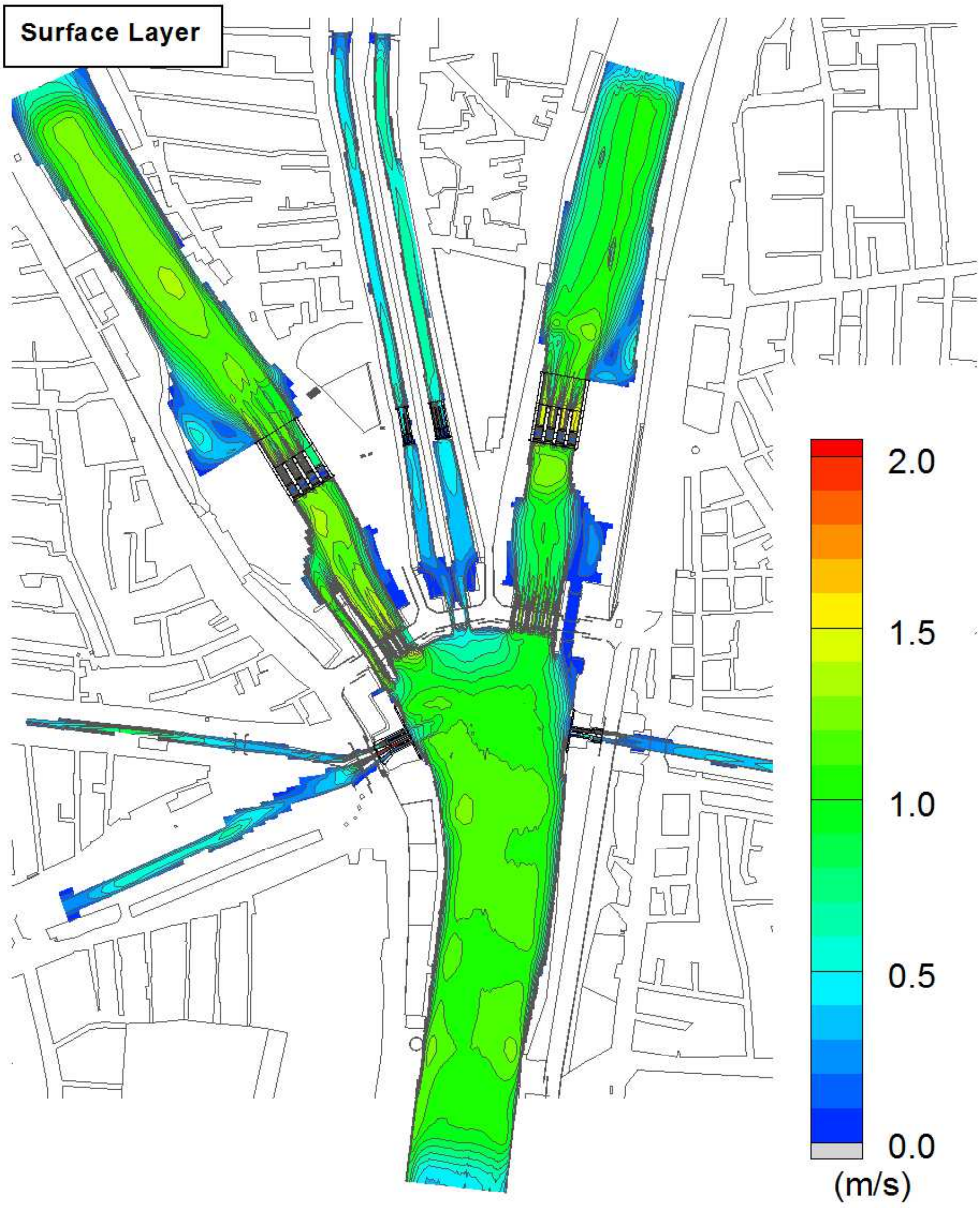
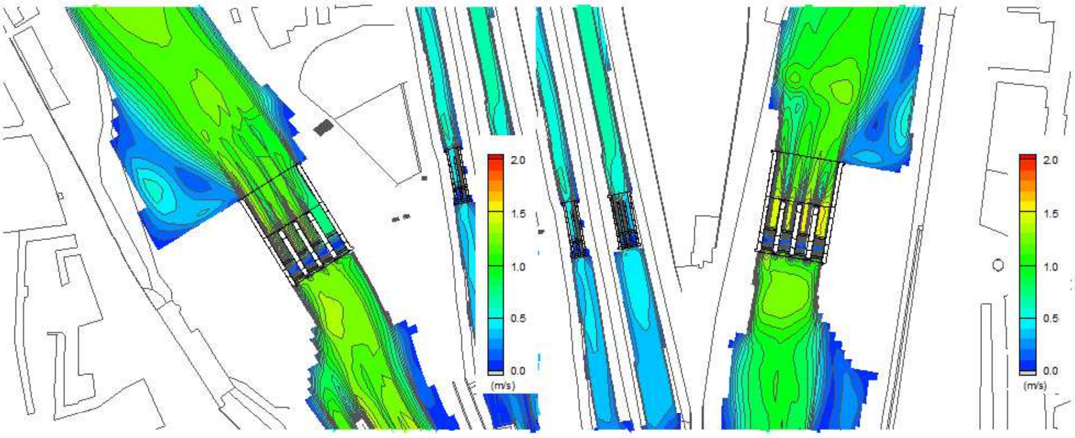


Figure 2-2.35 Comparison between the calculation results (calc) and observed results (target) of the discharge volume and the average water level at the observation sections

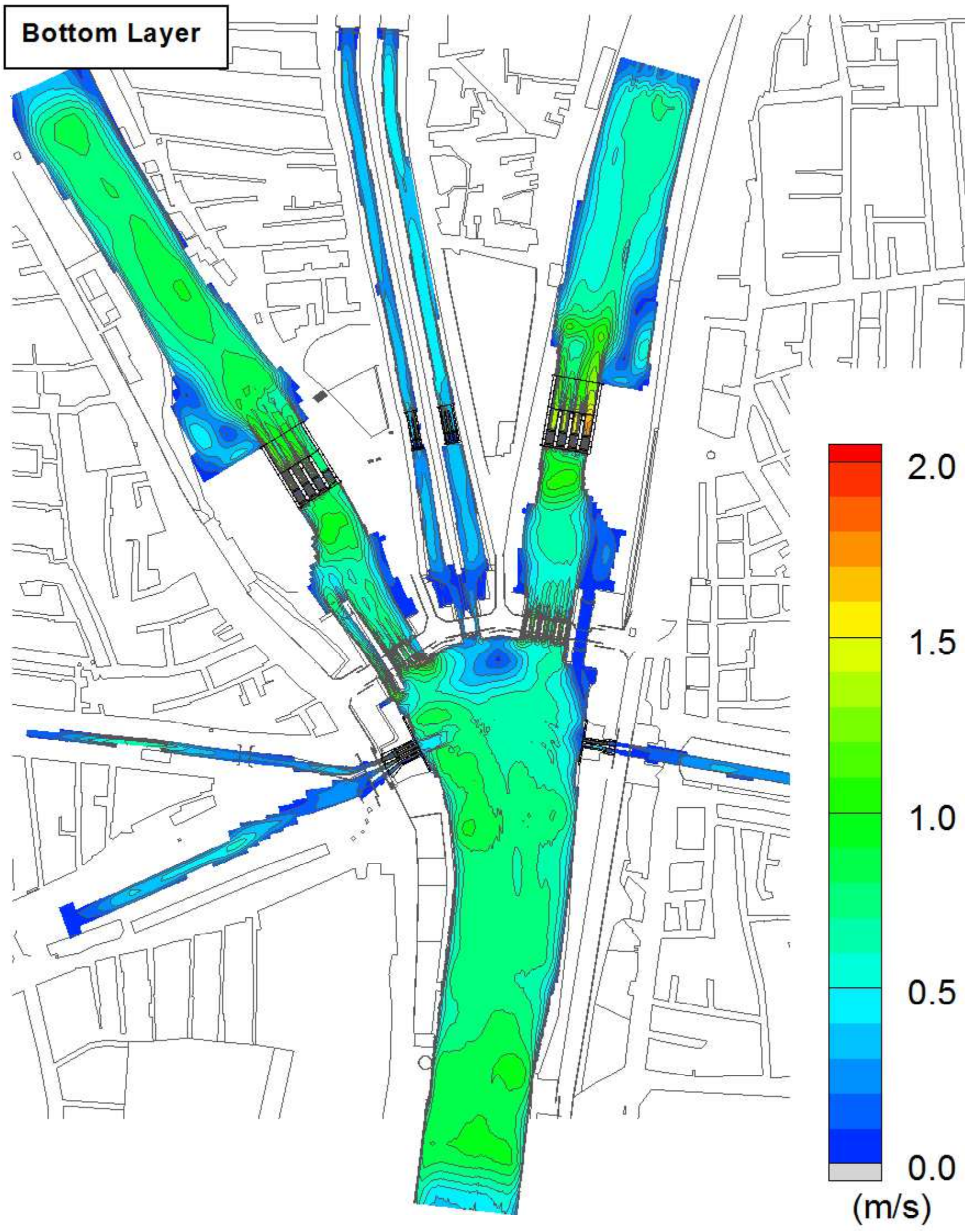


(a) All area

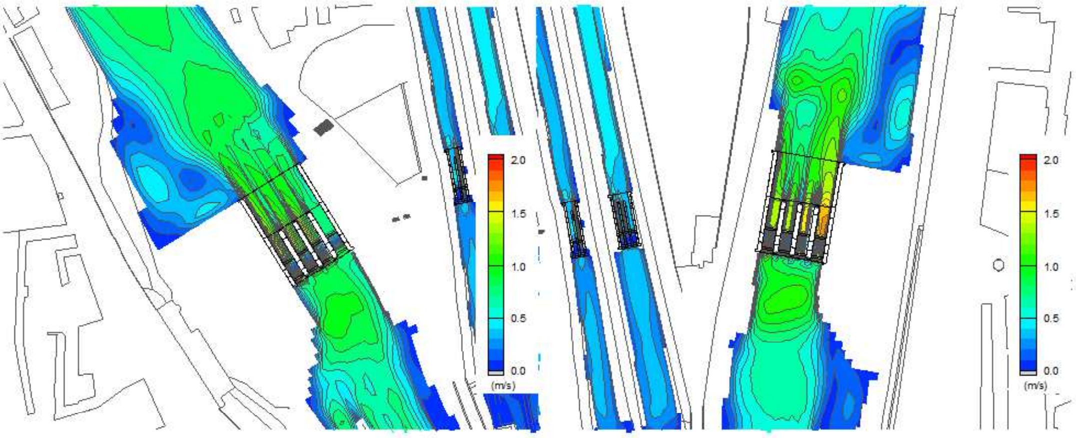


(b) Bahr Yusef new regulator (c) Ibrahimia new regulator

Figure 2-2.36 Velocity contour map of the surface layer at the planning stage



(b) All area



(b) Bahr Yusef new regulator (c) Ibrahimia new regulator

Figure 2-2.37 Velocity contour map of the bottom layer at the planning stage

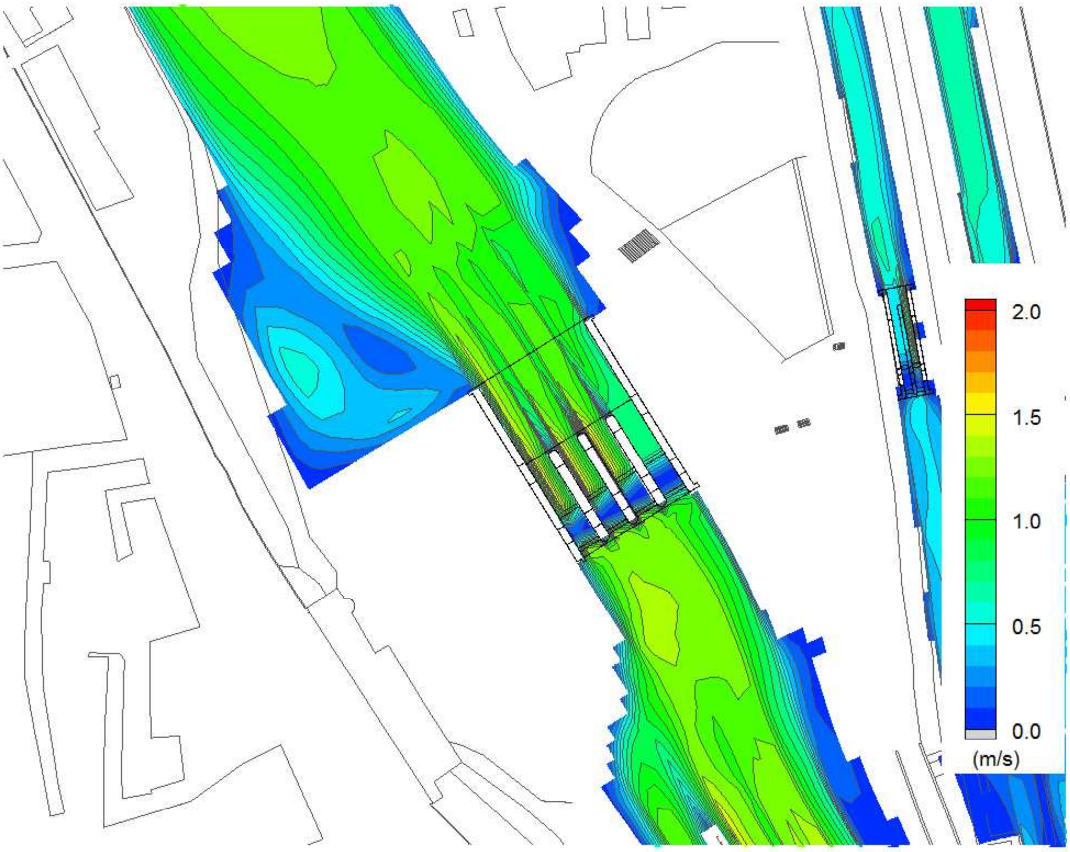


Figure 2-2.38 Velocity contour map of the surface layer at the planning stage (around the new Bahr Yusef regulator)

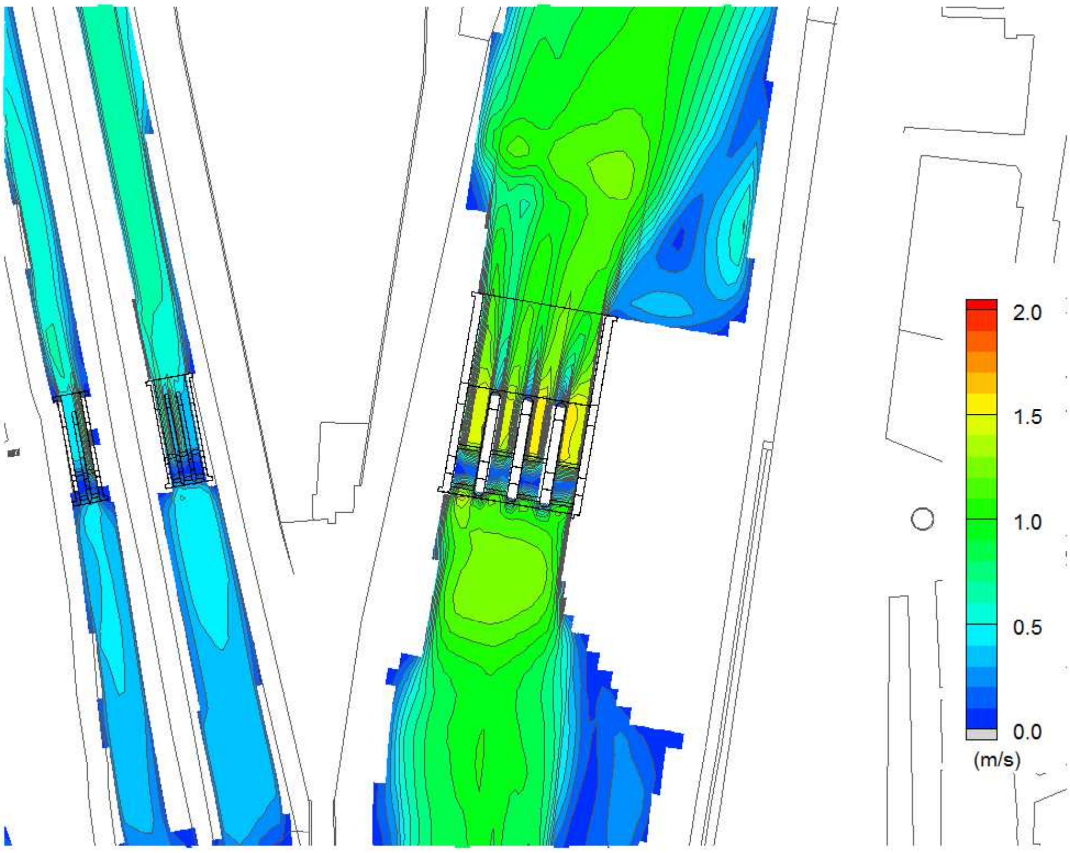


Figure 2-2.39 Velocity contour map of the surface layer at the planning stage (around the new Ibrahimia regulator)

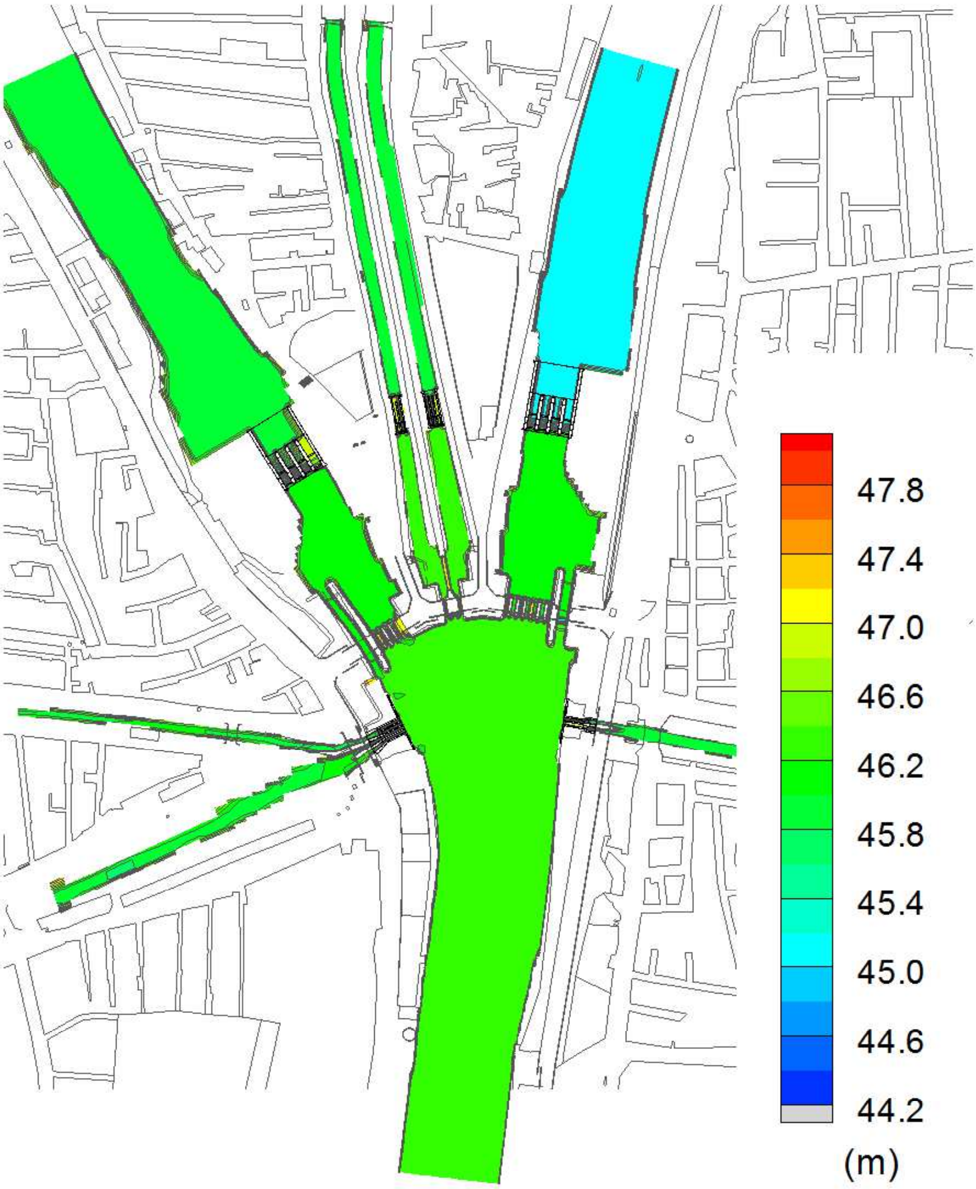


Figure 2-2.40 Water level contour map at the planning stage

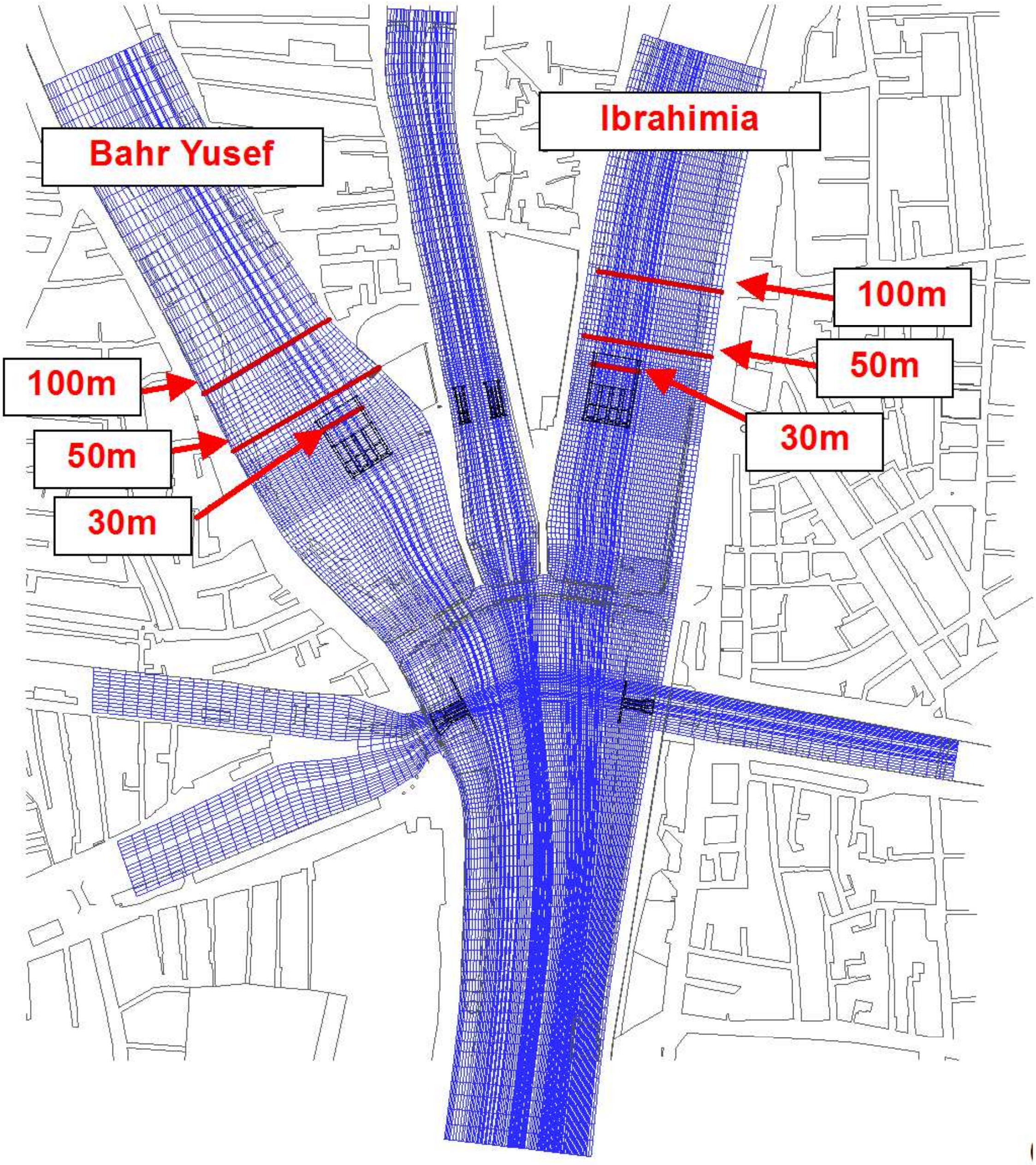
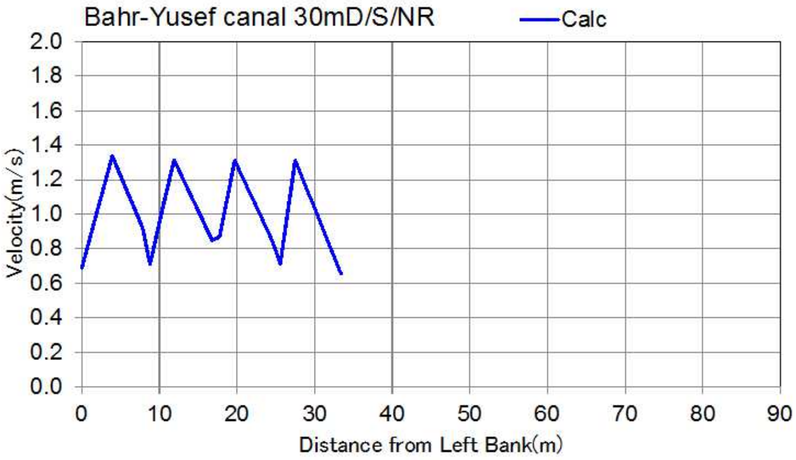
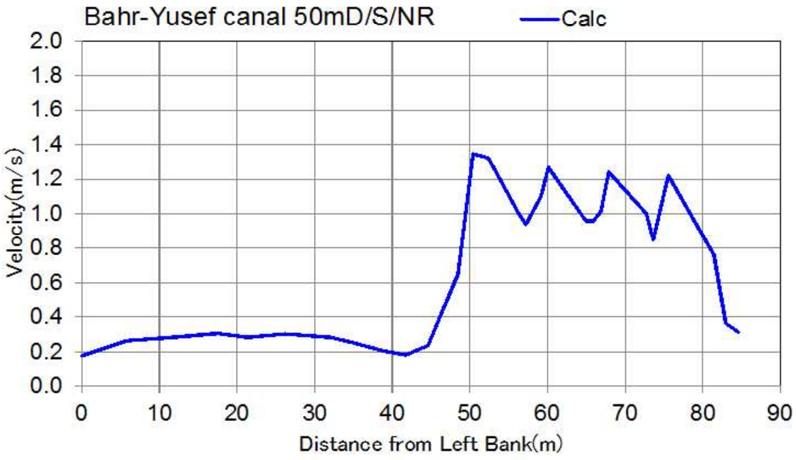


Figure 2-2.41 Location of the cross-sectional lines





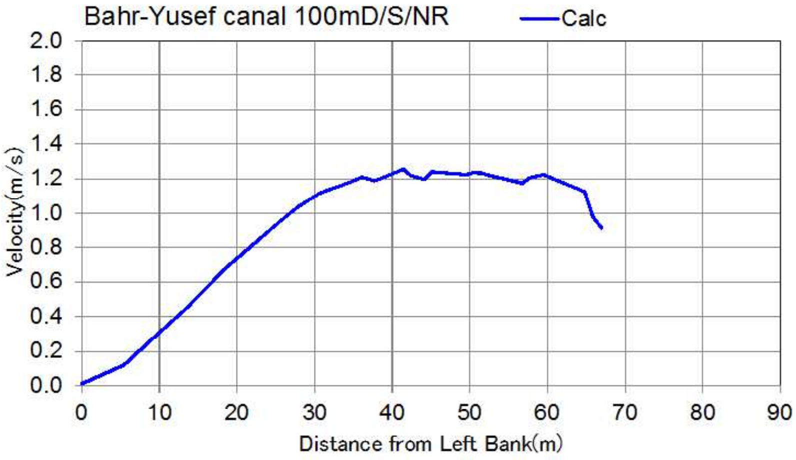
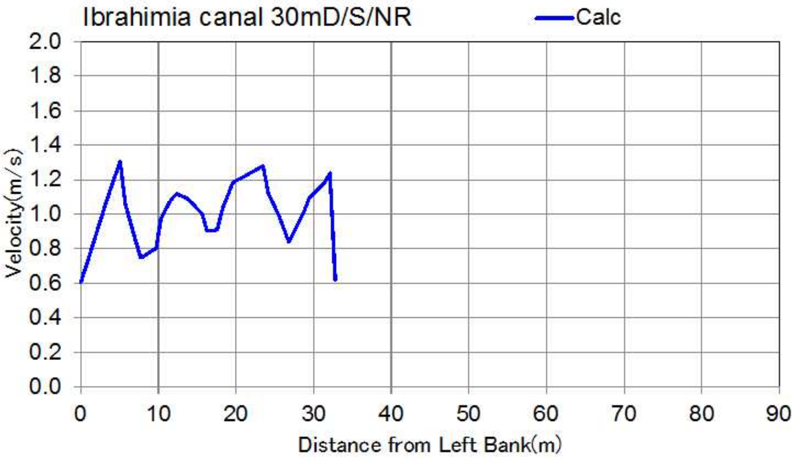
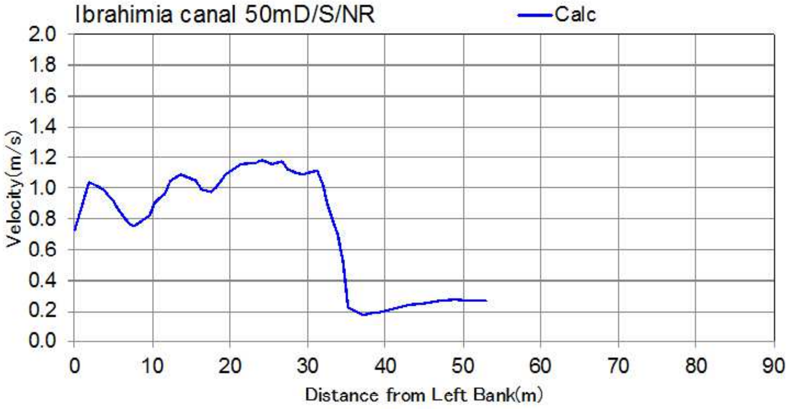


Figure 2-2.42 Cross-sectional velocity
(Bahr Yusef canal 30, 50, 100m downstream of the new regulator)





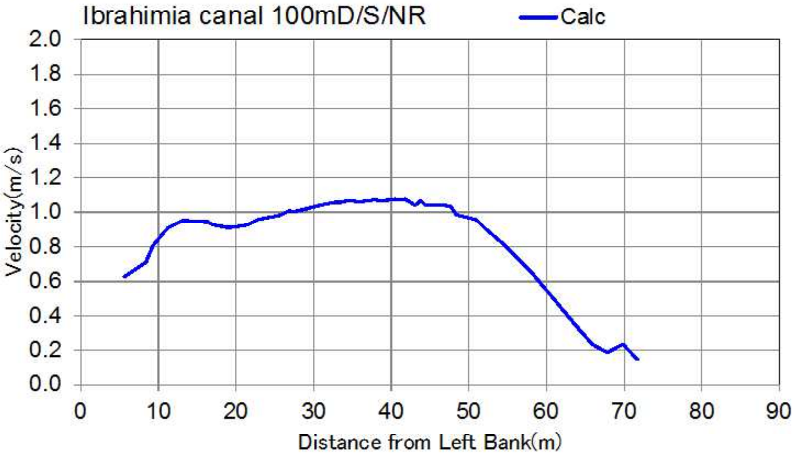


Figure 2-2.43 Cross sectional velocity
(Ibrahimia canal 30, 50, 100m downstream of the new regulator)

6) Analysis of flow situation after changing sill elevation of upstream small-scale regulators

After the basic design was settled, RGBS requested to change sill elevation values of two upstream small-scale regulators to a lower height. After examining the possibility, it was decided to change the elevation values as described below. This flow situation analysis was conducted at the design stage in order to confirm the impacts of changing sill elevations of the two upstream small-scale regulators.

Survey values acquired in January 2016 in the same topographic map as in that to which the regulator design was applied were used for survey data such as canal conditions.

a) Analysis conditions

For comparison of the results of tests using the both models, the following conditions are applied in the flow situation analyses. The analyses for the comparison were made for the new Dirout Group of Regulators (in the design stage).

Table 2-2.9 Analytical conditions

Analysis Conditions	Basic Design Report (BDR)	Analysis for Comparison
1. Topographic data	January 2016	Same as BDR
2. Number of meshes	198,380 meshes in total	Same as BDR
3. Boundary conditions	Upstream side of existing regulators: Discharge End of each canal: Water level	Same as BDR
4. Water level discharge	Design stage (new regulators)	Same as BDR
5. Sill elevation value of 2 upstream small-scale regulators	New Abo Gabal Regulators: EL. 44.15m New Saheliya Regulators: EL. 44.65m	New Abo Gabal Regulators: EL. 43.6m New Saheliya Regulators: EL. 43.0m

i) Topographic conditions

The topographic data from the survey conducted in January 2016 was applied. (Fig. 2-2.44)

ii) Number of meshes

The total number of meshes was the same as described in the Basic Design Report. (Fig. 2-2.45)

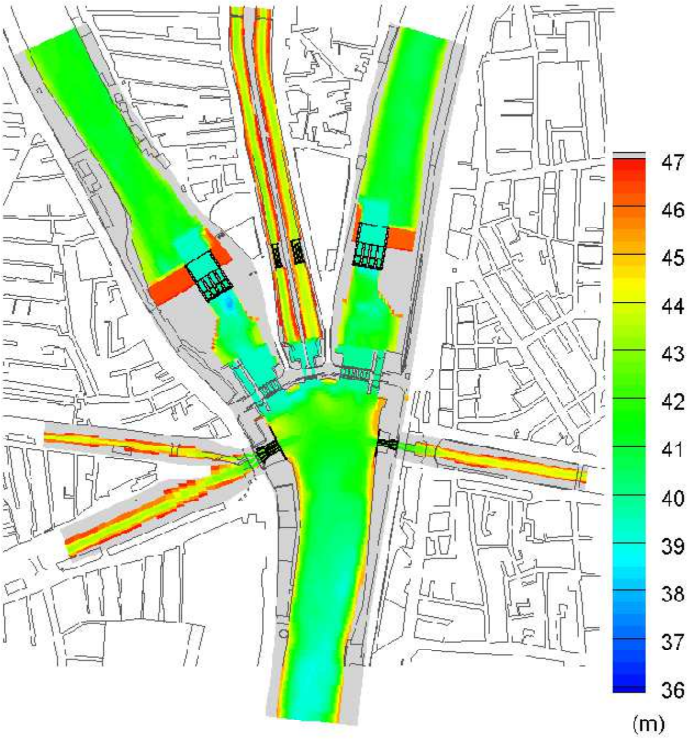


Figure 2-2.44 Topographic map (design in January 2016 – new regulators)

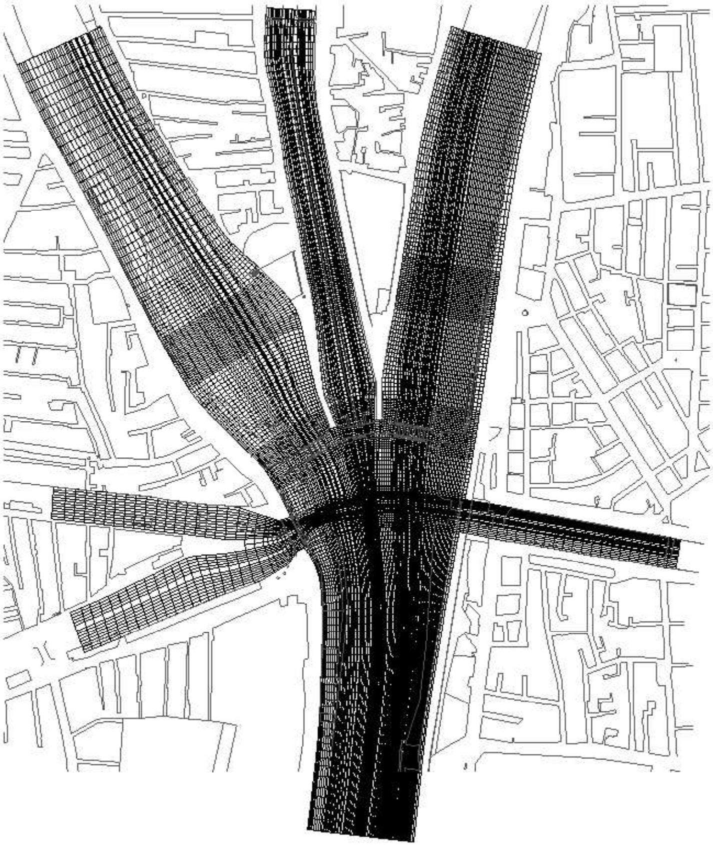


Figure 2-2.45 Canal meshes map

iii) Boundary conditions

The boundary conditions are as follows:

- Discharge boundary: Upstream side of the existing regulators
- Water level boundary: At each canal end

iv) Water level, inflow in each regulator and discharge from each new regulator

The water level applied as the water level boundary is based on the data of the Water Allocation Bureau as shown in Table 2-2.10 (this is also applied to the design of the new regulators). The discharge boundary is 455 m^3/s at the upstream end.

Table 2-2.10 Water level, inflow in regulators and discharge from new regulators

Item	US. of Regulators	DS. of regulators							Remarks
	existing DGRs	Bahr Yusef	Ibrahimia	Badraman	Diroutiah	Abo Gabal	Irad Delgaw	Sahelyia	
Water Level (m)	46.30	45.82	45.13	45.90	45.90	45.90	45.90	45.90	Target Value
Inflow (m^3/s)	455	—	—	—	—	—	—	—	Up stream
Outflow of regulator (m^3/s)	—	27	186	9	12	7	9	5	Target Value

b) Analysis results and evaluation

It was discovered that, even if the sill elevation of the upstream small-scale regulators was changed, the discharge conditions in the vicinity of the regulators had no change because the inflow quantity into each small-scale canal was controlled to the same quantity as before the change of the sill elevation value. Therefore, it can be said that the change of the sill elevation of the two upstream small-scale regulators has no impact on the design discharge.

The discharge comparison maps of the DGRs are shown in Figure 2-2.46, the discharge comparison maps of the vicinity of the new Abo Gabal regulators in Figure 2-2.47, and the discharge comparison maps of the vicinity of the new Saheliya regulators in Figure 2-2.48. Each figure shows that the discharge has no change before and after the change of the sill elevation.

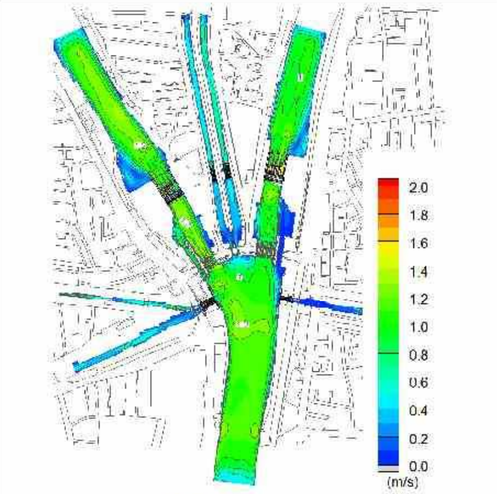
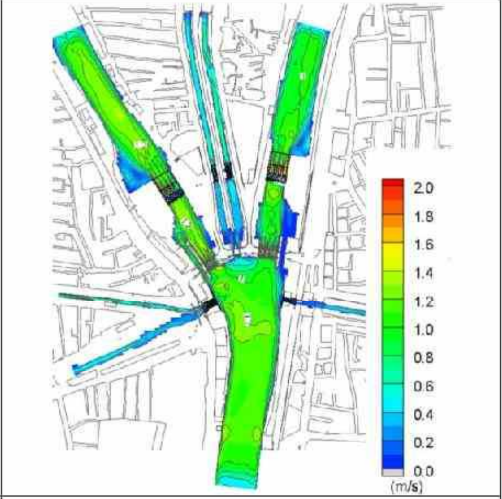
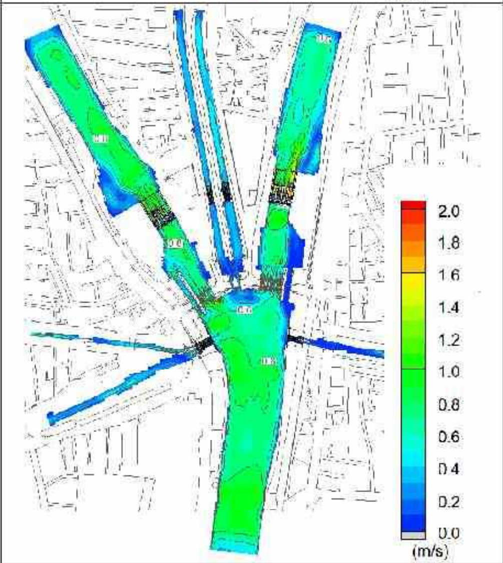
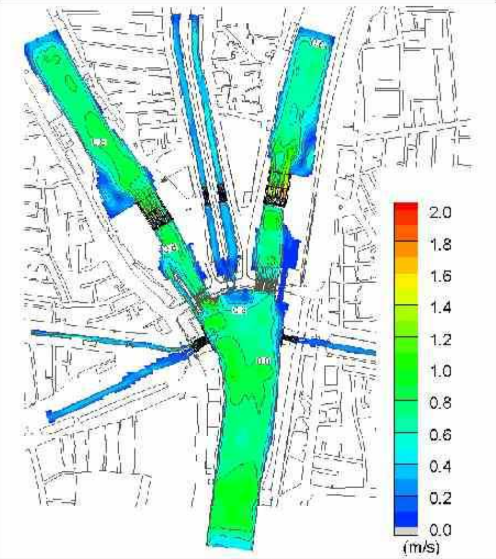
Surface layer	 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0 (m/s)	 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0 (m/s)
Bottom layer	 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0 (m/s)	 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0 (m/s)
	Before changing of sill elevation	After changing of sill elevation

Figure 2-2.46 Discharge comparison maps of DGRs

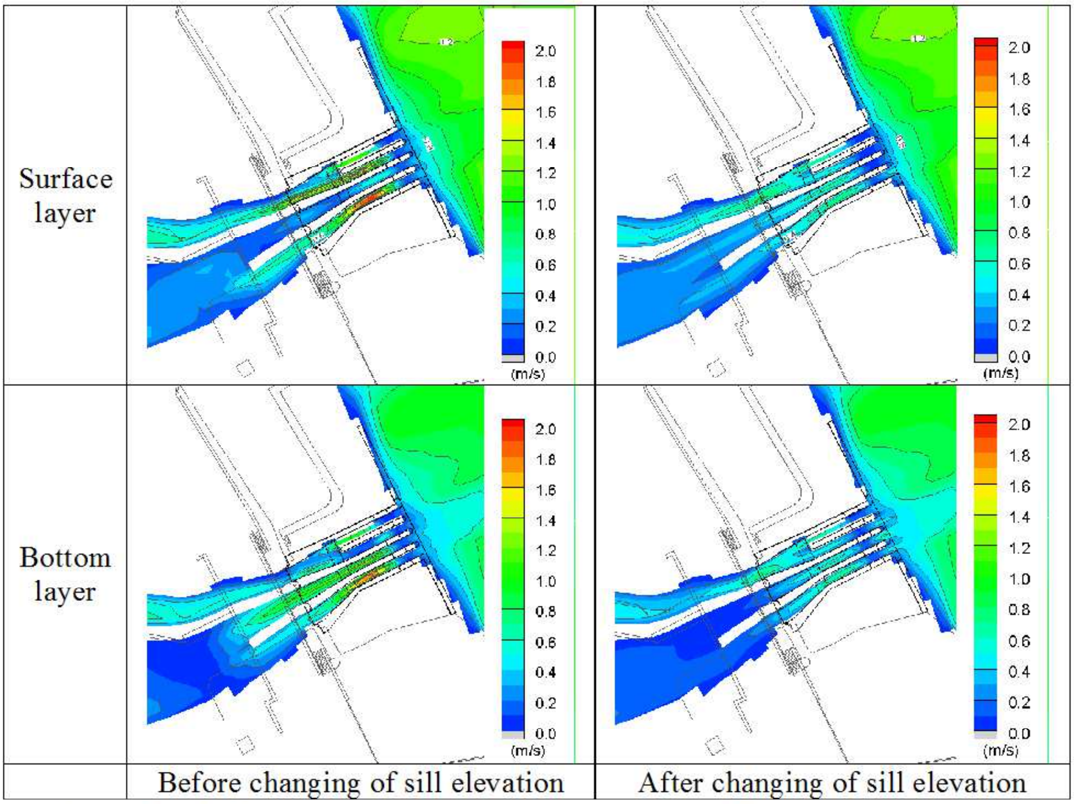

Surface layer
Bottom layer
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
(m/s)
Before changing of sill elevation
After changing of sill elevation

Figure 2-2.47 Discharge comparison maps of vicinity of new Abo Gabal regulator

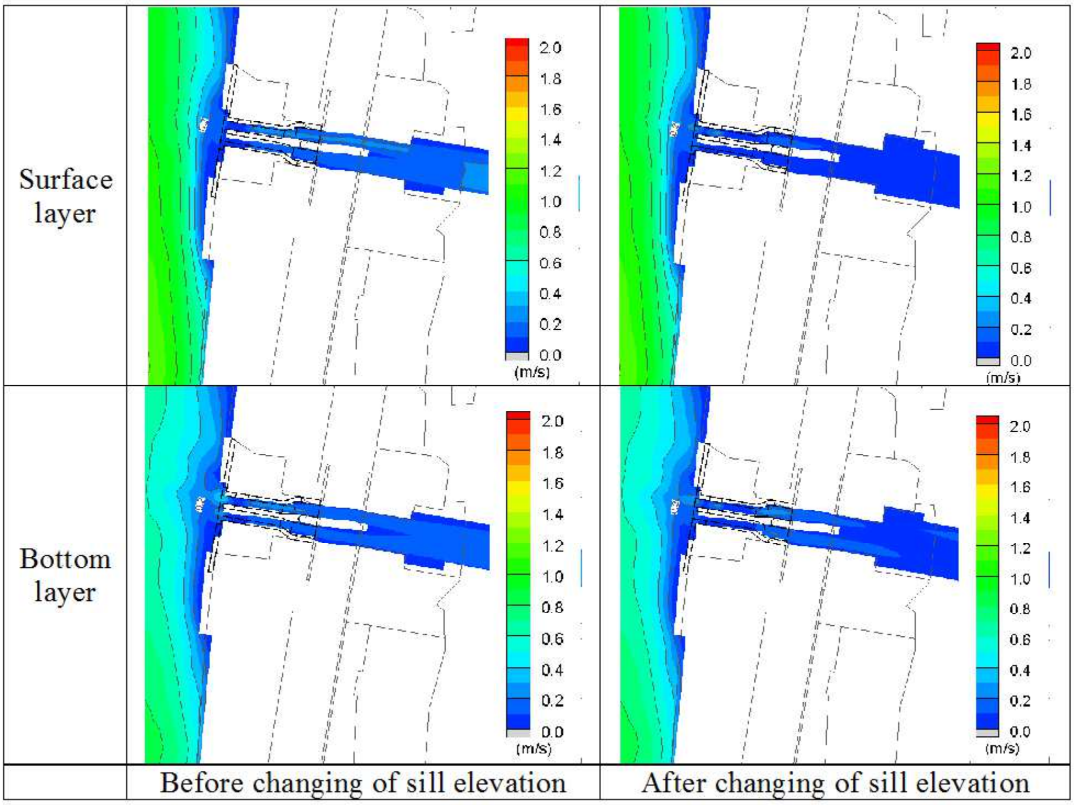

Surface layer
Bottom layer
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
(m/s)
Before changing of sill elevation
After changing of sill elevation

Figure 2-2.48 Discharge comparison maps of vicinity of new Saheliya regulator

7) Installation of guiding wall at the two upstream small-scale regulators

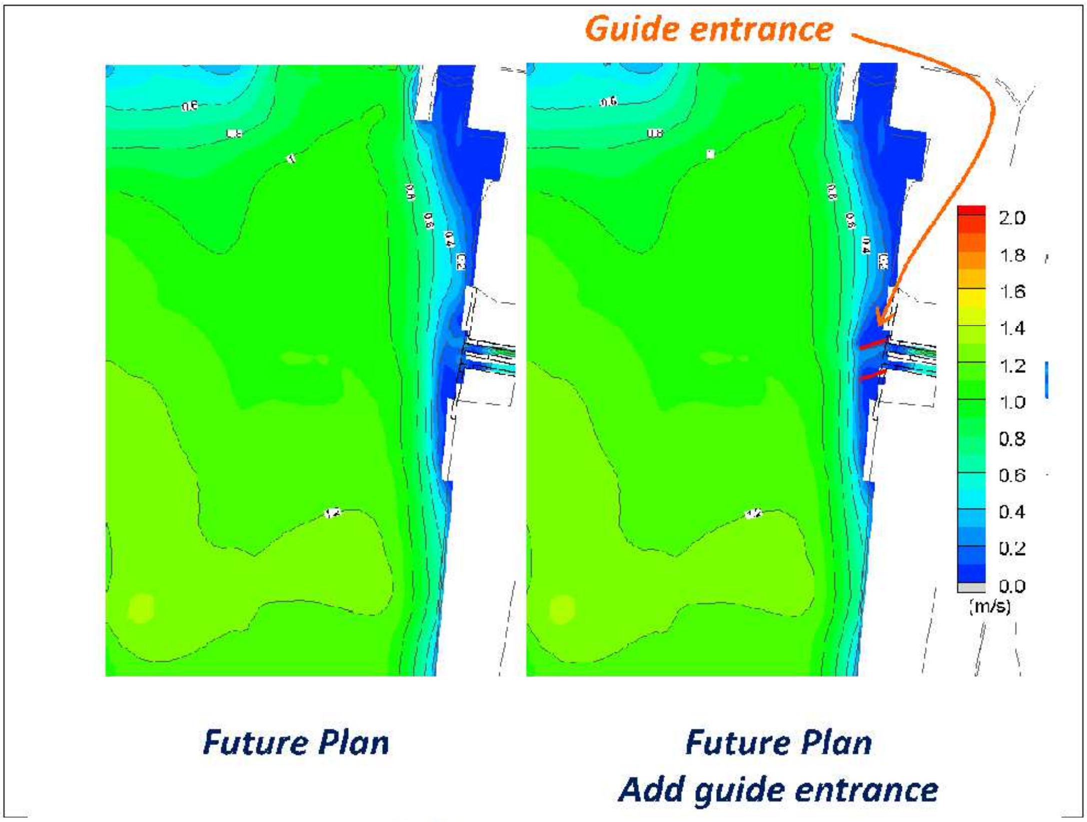
In the two upstream small-scale regulators of the DGRs, sedimentation occurs on the front of the regulators, and there is concern that the water intake function will decline.

The planned facility is to be installed on the front of the existing regulator to reduce the influence of sediment and ensure effective water intake.

The hydrological analysis confirmed that planned intake and sedimentation on the front of the new regulator would decrease.

On the other hand, to further stabilize the water intake function, a proposal was made to install a flow-guiding wall at the front of the intake regulator. The pros and cons of this proposal are discussed below.

For the Sahelyia regulator with a maximum discharge of 5 m^3/s, a flow condition analysis was conducted under the conditions of the designed discharge when a flow-guiding wall of about 6m was installed in front of the new regulator. The flow velocity contour map is shown below.



Future Plan

Future Plan
Add guide entrance

Figure 2-2.49 Flow velocity contour map
(when 10 m flow-guiding wall is installed on the front of the new Sahelyia regulator)

i) Intake

Before installing the flow-guiding wall, the front side of the regulator had a slow flow region with a flow velocity of 0.2m/s or less and in the absence of approaching flow velocity, intake discharge was present.

The analysis conducted with the guiding wall showed that the 10m wall only caught the slow flowing water that moved at a flow velocity of 0.2m/s or less, and that the desired effect of increasing the water intake discharge due to the installation of the guiding wall was only minimally achieved. Therefore, the installation of the guiding wall to the two upstream small scale regulators was judged to be inutile.

However, the installation of a guiding wall would make it possible to withdraw water exceeding the planned water intake discharge.

ii) Sedimentation

The installation of the guiding wall has potential negative impacts, such as: the expansion of the sediment-catching range due to the aggressive introduction of sediment into the canal, and the reduction of sediment removal efficiency at the front of the regulator.

iii) Other

The installation of a flow-guiding wall will increase construction costs.

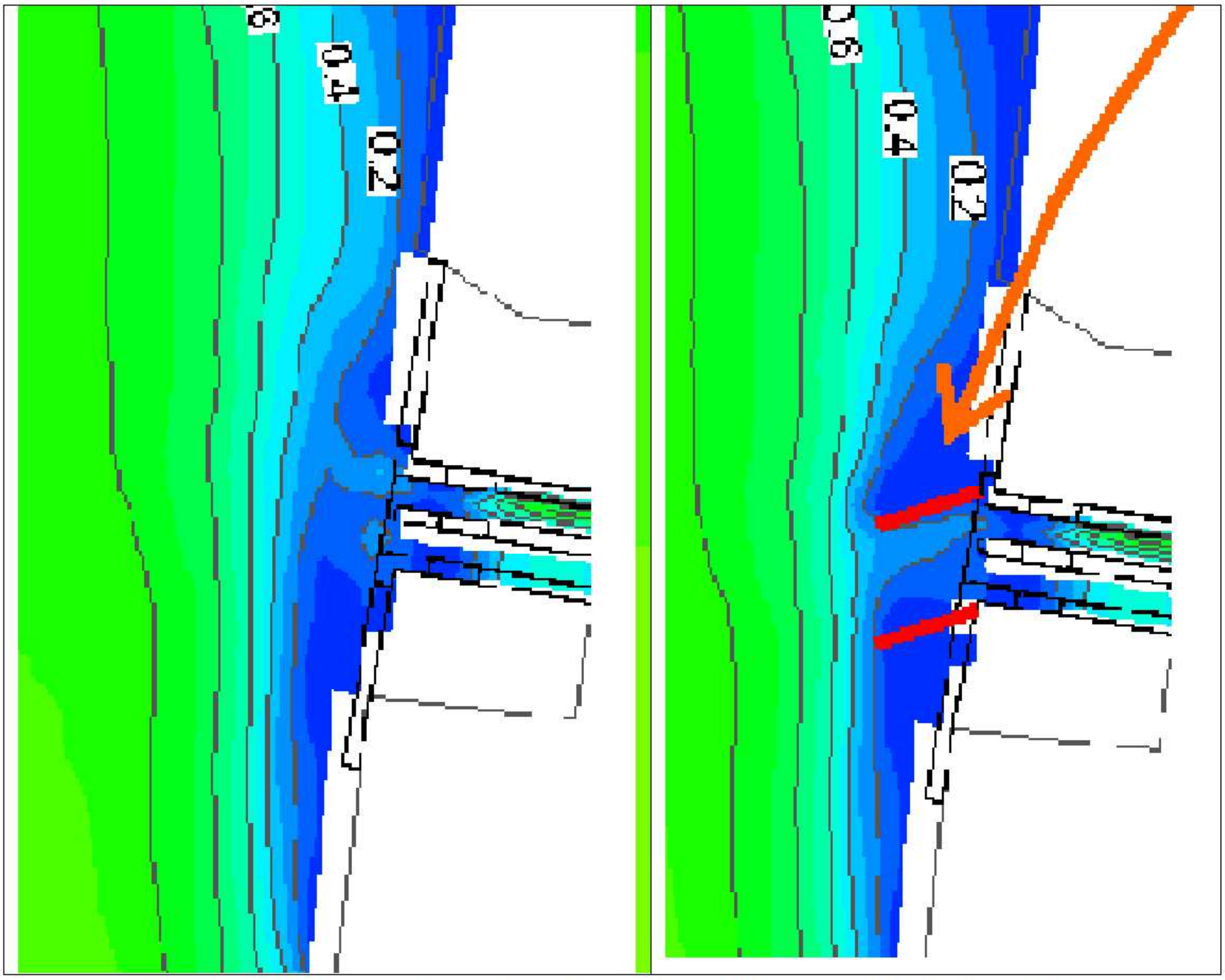


Figure 2-2.50 Flow velocity contour map (around the new Sahelyia regulator)

8) Impacts of navigation lock opening of existing Ibrahimia regulator on the new Sahelyia regulator and new Ibrahimia regulator

Navigation lock is installed in the existing Bahr Yusef regulator and the existing Ibrahimia regulator and are closed at present. After construction of the NDGRs, the navigation lock of the existing Bahr Yusef regulator will be opened; nevertheless, it was presumed that the navigation lock of the existing Ibrahimia regulator would remain closed because the neighboring area of these navigation locks would be used for another purpose after the surrounding area of the new DGRs is redeveloped. The hydraulic analysis was also made on the condition that there was no discharge from this navigation lock.

As a result, it was discovered that the flow velocity tended to be a little gentle in the front of the new Sahelyia regulator located on the upstream side of the existing Ibrahimia regulator and that the bottom flow velocity might be concentrated at the right-bank gates of the new Ibrahimia regulator.

This analysis was conducted to confirm the flow situation in the front of the new Sahelyia regulator and in the vicinity of the new Ibrahimia regulator by performing hydraulic analysis on the condition that the navigation lock of the existing Ibrahimia regulator were open.

a) Analysis conditions

The analysis conditions were the same as in the basic design, using the survey data in January 2016, the maximum discharge in the design stage and the sill elevation of the two (2) upstream small-scale regulators in the basic design.

b) Analysis results and evaluation

If the navigation lock of the existing Ibrahimya regulator is open, it was found that the flow in the front of the new Sahelyia regulator directed toward its sides and that the concentration of the bottom flow velocity on to the right-bank gates of the new Ibrahimia regulator was alleviated.

The discharge comparison maps of the upstream and downstream sides of the existing Ibrahimia regulator are shown in Figure 2-2.51, the discharge comparison maps of the new Sahelyia regulator in in Figure 2-2.52 and the discharge comparison maps of the new Ibrahimia regulator in Figure 2-2.53.

From these results, it can be said that it is better to open the navigation lock of the existing Ibrahimia regulator.

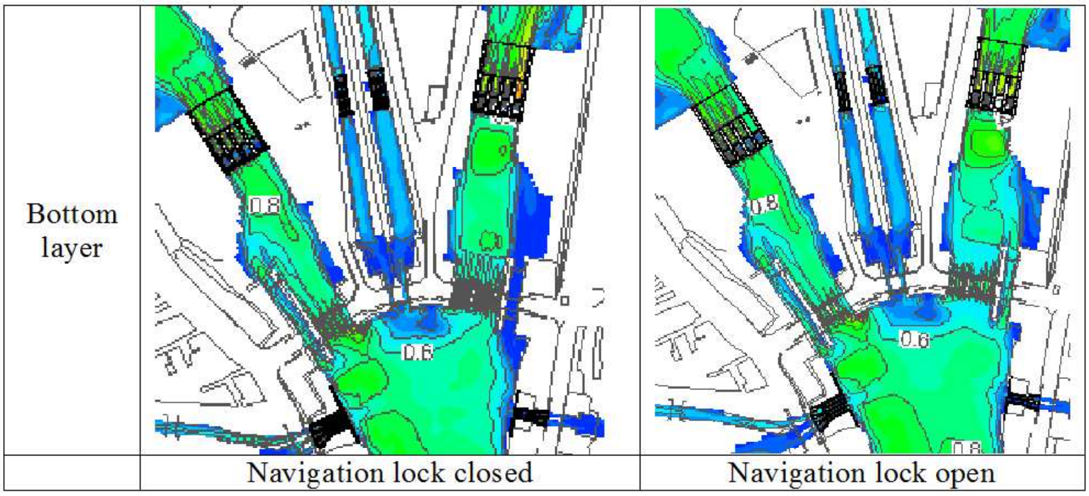


Figure. 2-2.51 Discharge comparison maps of upstream and downstream sides of existing Ibrahimia regulator

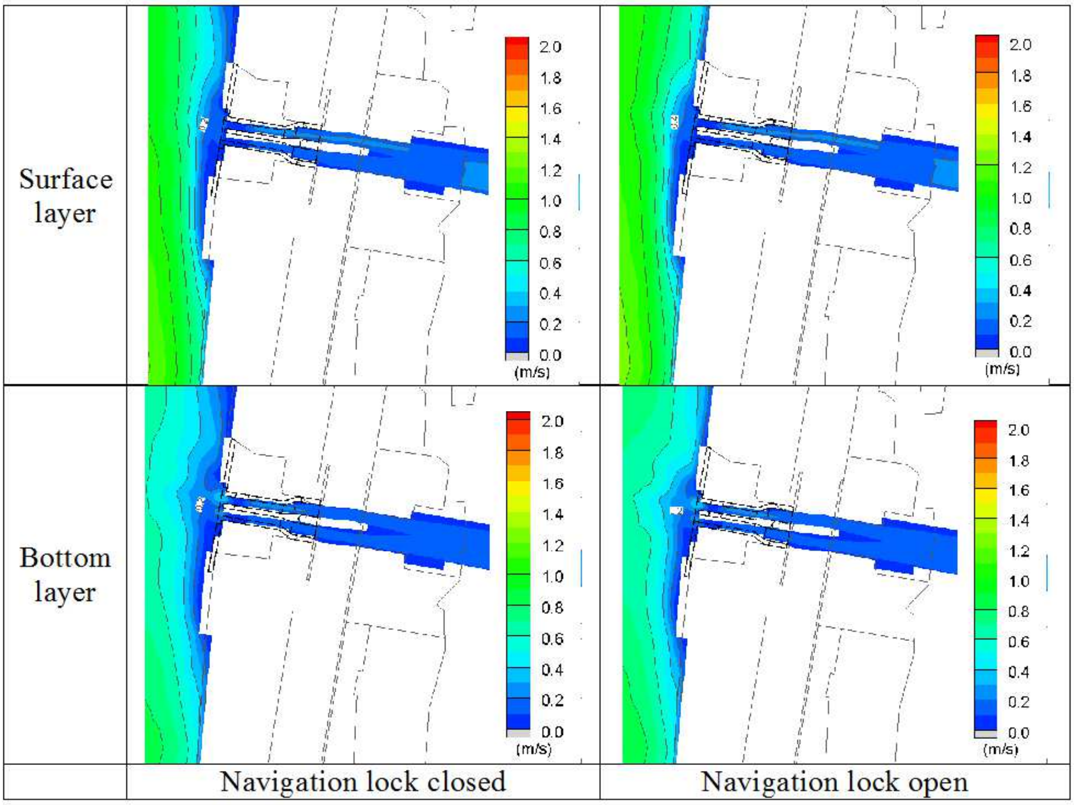


Figure 2-2.52 Discharge comparison maps of new Sahelyia regulator

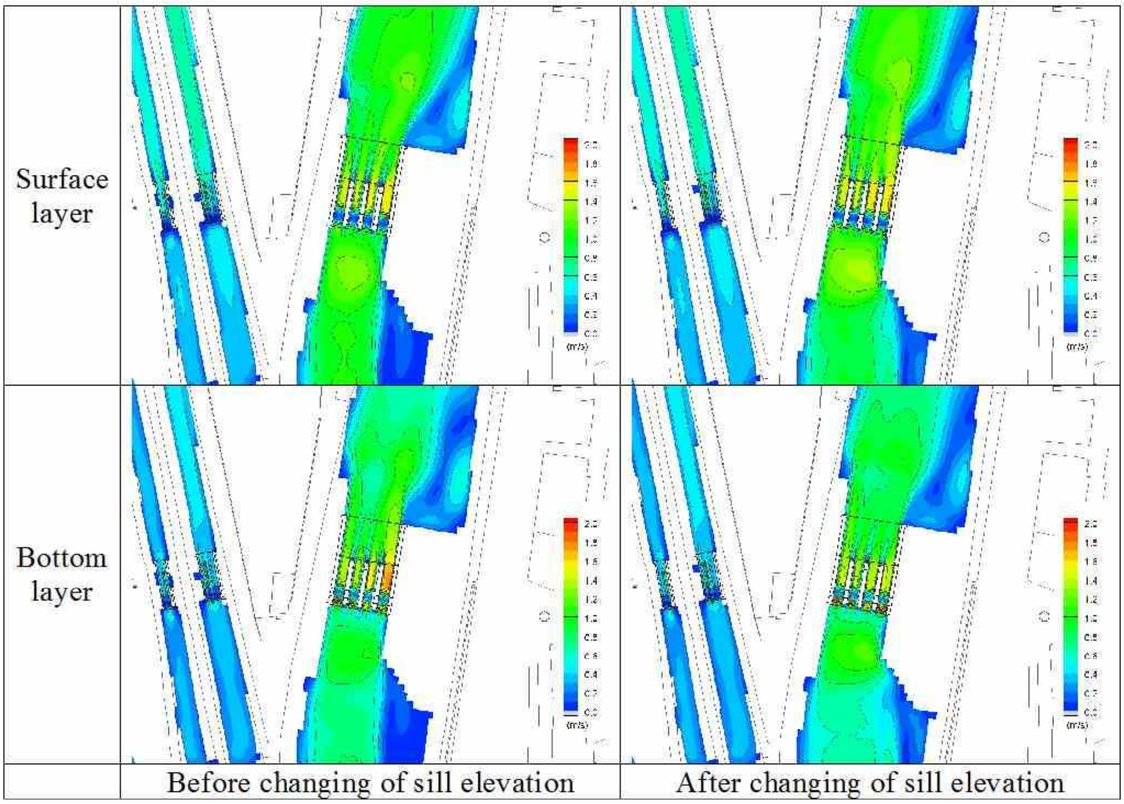

Surface layer
Bottom layer
Before changing of sill elevation
After changing of sill elevation
(m/s)

Figure 2-2.53 Discharge comparison maps of new Ibrahimia regulator

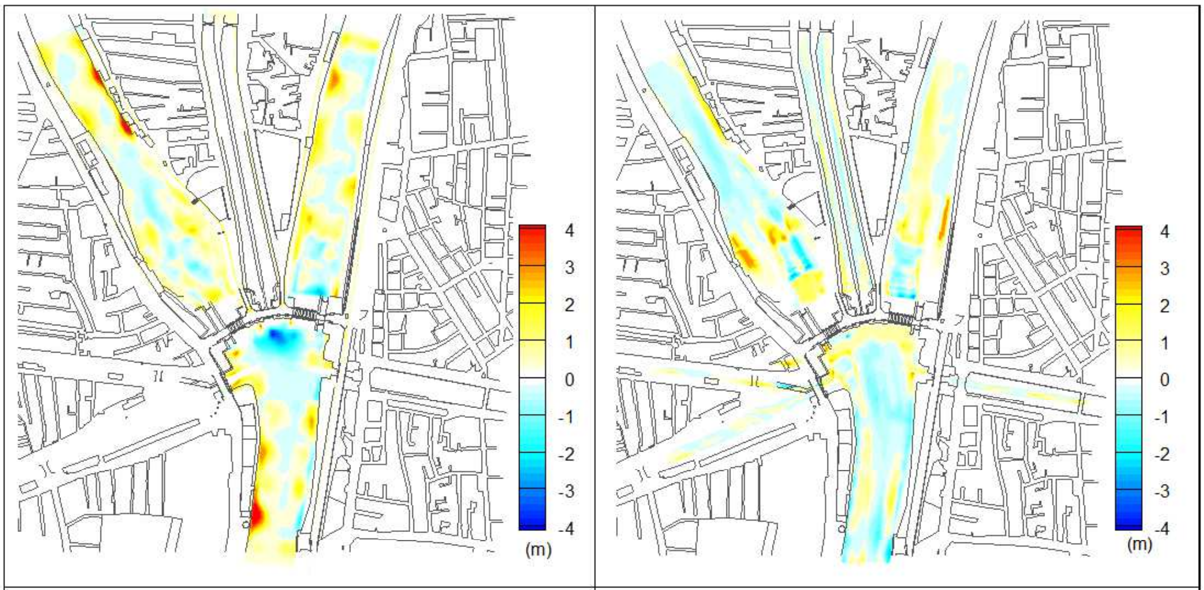
(2) Riverbed Variation Analysis

a) Analysis Results

1) Calibration

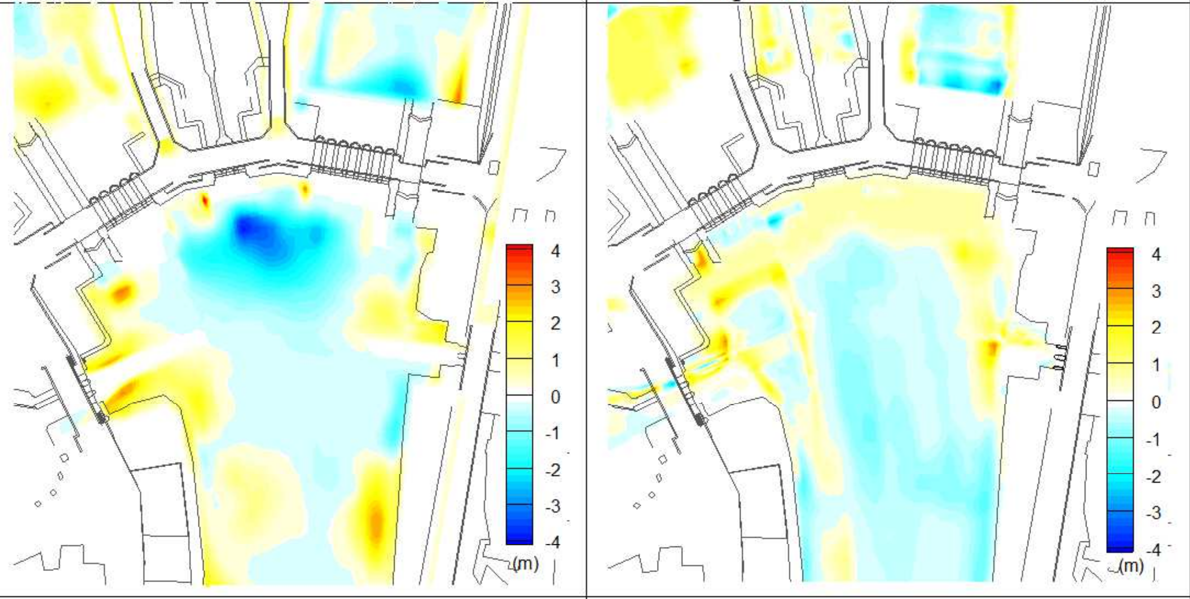
Taking the riverbed in January 2016 to be the initial riverbed for calibration, calculations were made for 11 months. Figure 2-2.54 shows a comparison between the observed riverbed variations and the riverbed variations at the end of the computation. The results of the erosion in the middle of the diversion channel showed that there was discharge from the Badraman regulator and the Diroutiah regulator when the water level was low.

However, in the analysis, there was no record of the regulators' operations, and there was too little erosion recorded in the calculations. In contrast, deposition trends at the front and the side of the Abo Gabal regulator and in front of the Sahelyia regulator have been reproduced. The presence of erosion trends downstream of the Ibrahimia regulator was therefore confirmed, as exhibited in actual performance. From the above, this analysis is judged to have reproduced trends in riverbed variation around the DGRs.



Observation: Overall view

Computation results: Overall view



Observation: Enlarged view of area around existing regulators

Computation results: Enlarged view of area around existing regulators

Figure 2-2.54 Result of the riverbed variation analysis (calibration stage)

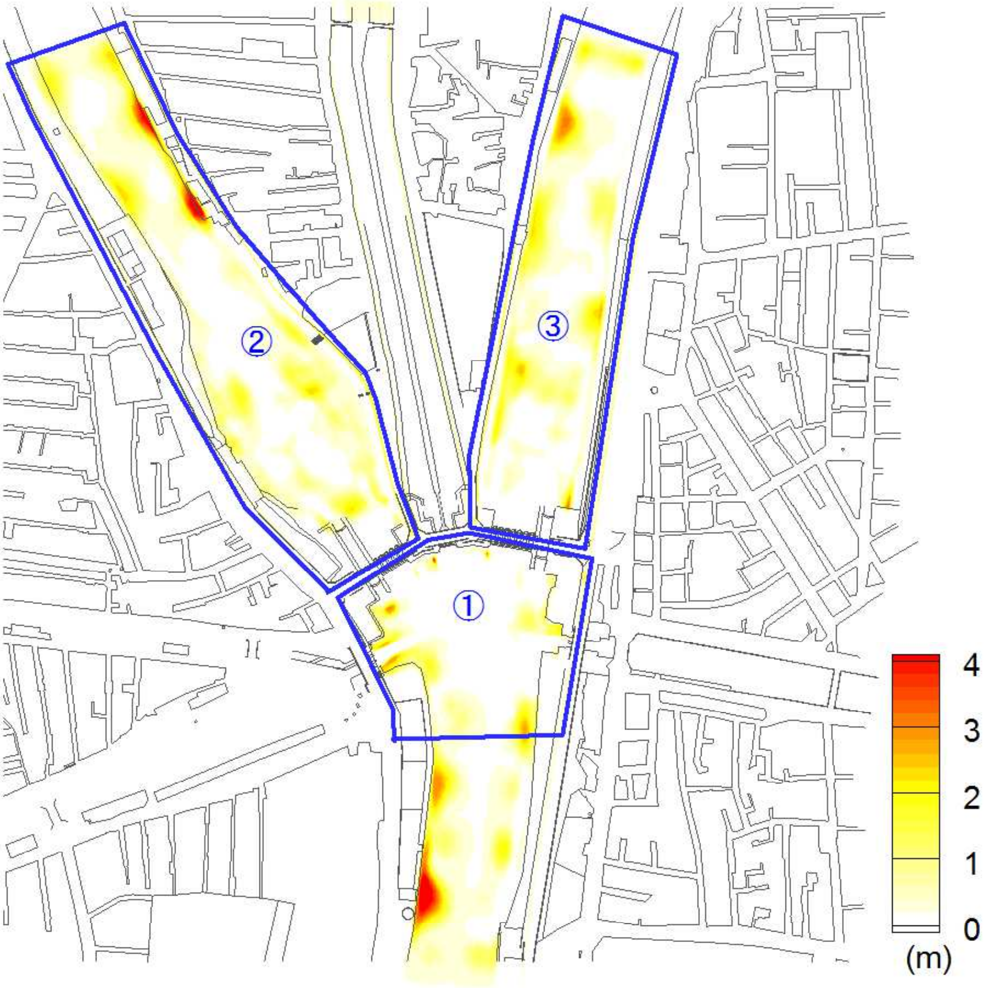


Figure 2-2.55 Distribution of sedimentation area

Table 2-2.11 Comparison of sediment volume

	Area	Sedimentation	
		Calc	Obs
①	Existing Regulator-Upstream150m	5,500	5,400
②	Bahr Yusef canal D/S	14,600	17,300
③	Ibrahimia canal D/S	10,100	12,400

(m^3)

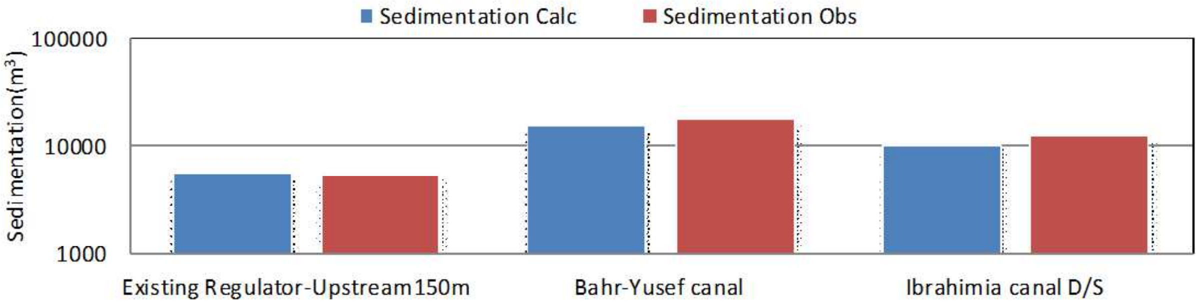
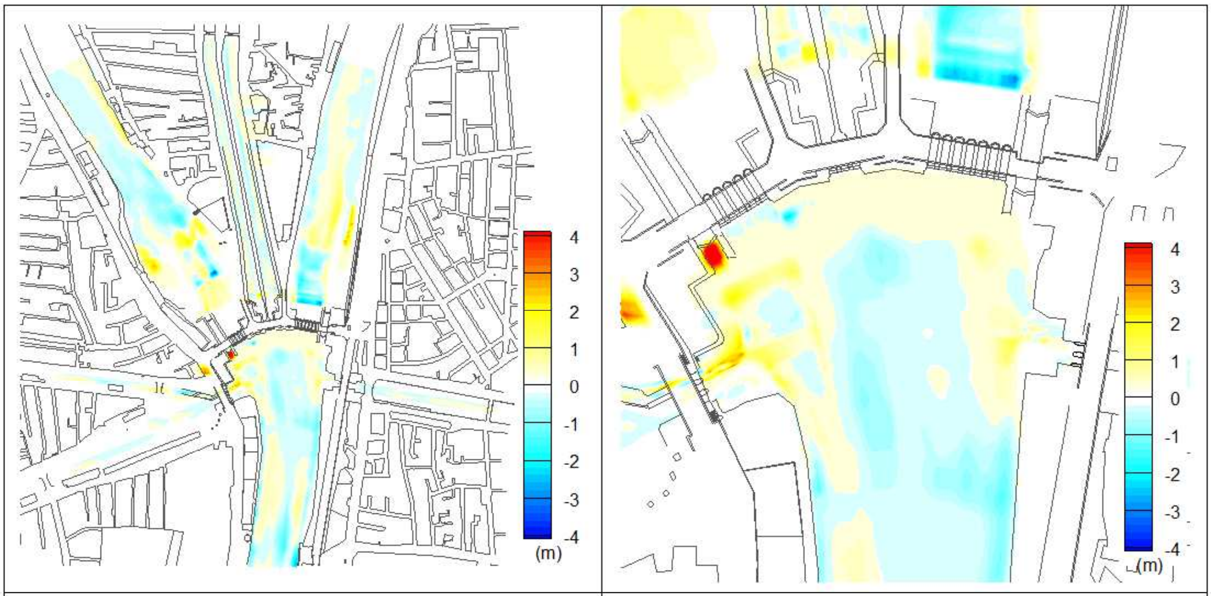


Figure 2-2.56 Comparison of sediment volume

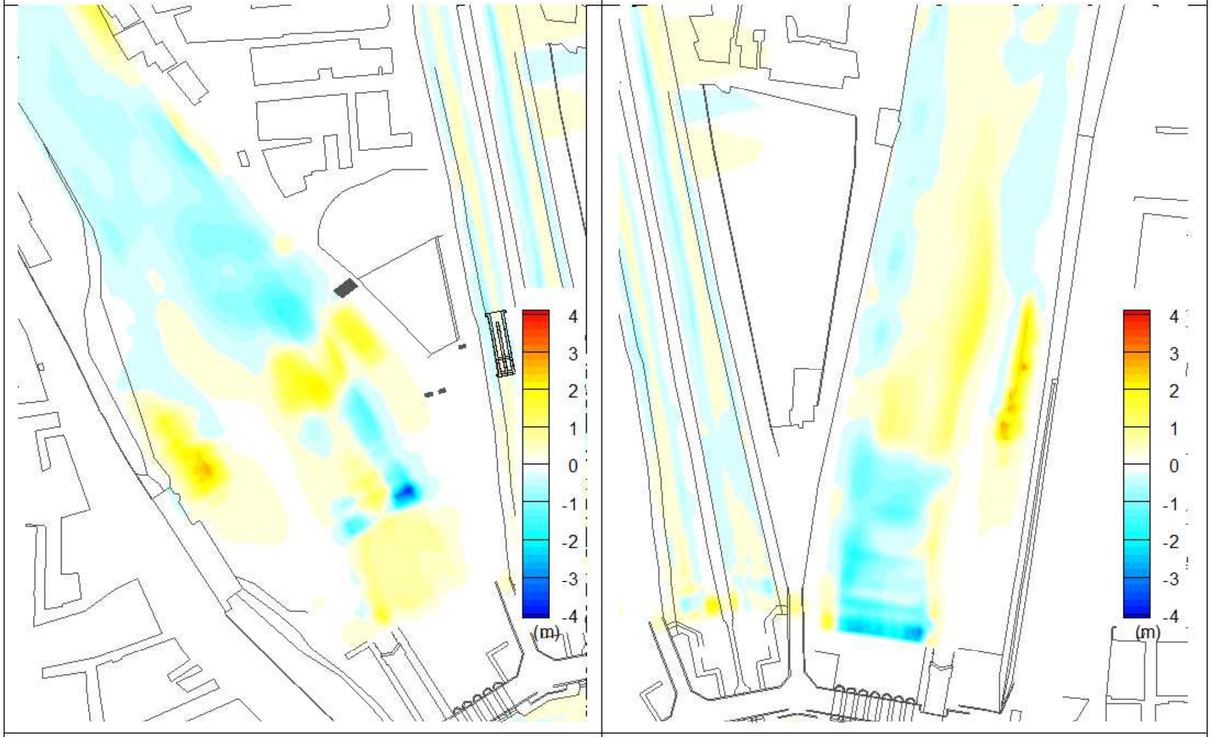
2) Present Conditions

Riverbed variation was calculated based on average discharges for one year under present conditions. Figure 2-2.57 shows the riverbed variations at the end of the computation. Deposition is relatively substantial at the Ibrahimia regulator, because suspended sediment flows down the regulator and accumulates around 120m downstream, where the water is deep and the current is slow.



Overall view

Enlarged view (around DGRs)



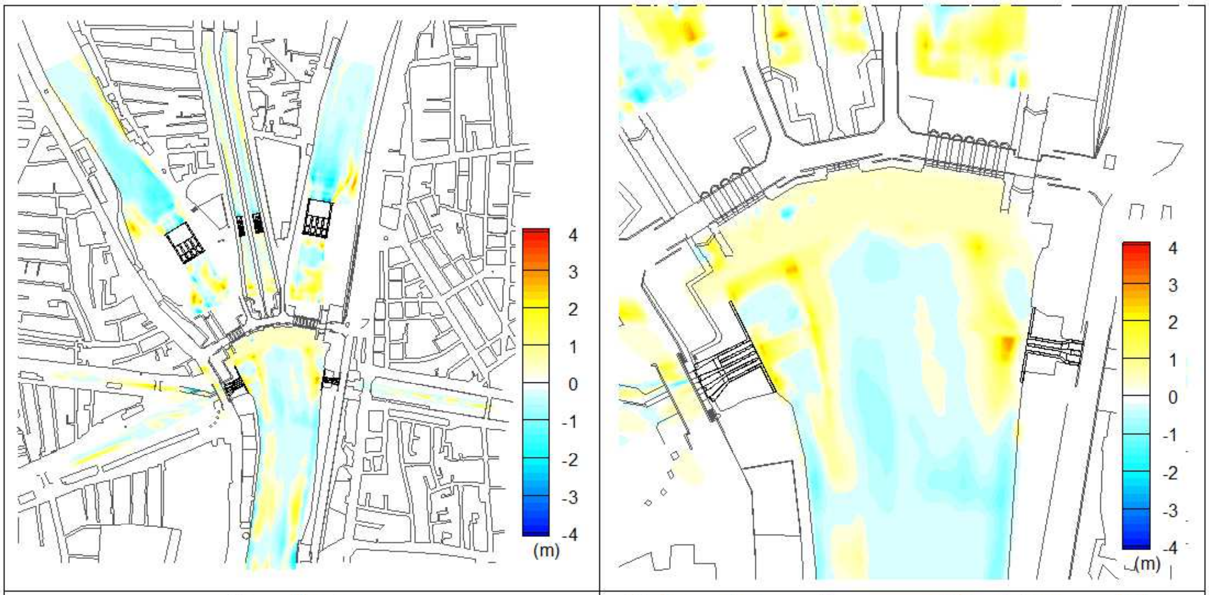
Area around channel downstream of Bahr Yusef regulator

Area around channel downstream of Ibrahimia regulator

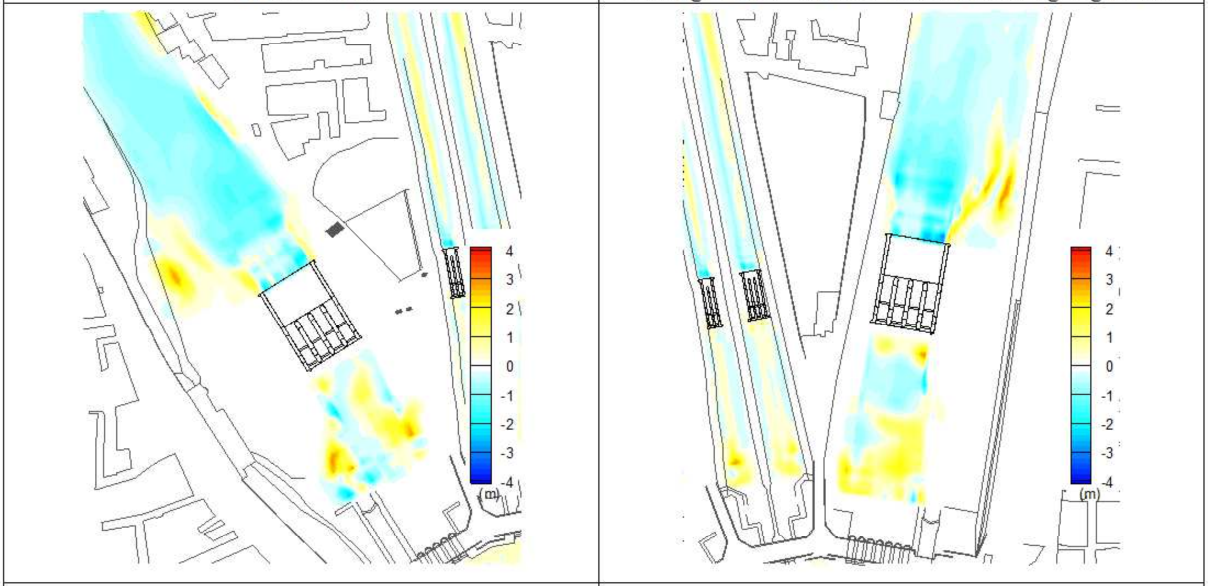
Figure 2-2.57 Result of the riverbed variation analysis (present state)

3) Planning

Similar to the previous calculations under present conditions, planned riverbed variation was calculated using the given average discharges for one year. Figure 2-2.58 shows the riverbed variations at the end of the computation. In the area around the diversion channels of the existing regulators, there is significant deposition in front of and at the side of the Abo Gabal regulator and on the side of the Ibrahimia canal. There is slight deposition in front of the new Ibrahimia regulator and relatively extensive erosion on the downstream of the new regulator. Relatively extensive erosion can be confirmed downstream of the new Bahr Yusef regulator. The Abo Gabal and Sahelyia regulators jut out along the canal banks where there are less slow-flowing areas. As a result, there is less deposition in front of and at the side of these regulators compared with the prediction results for the existing canals.



Overall view	Enlarged view of area around existing regulator



Area around new Bahr Yusef regulator	Area around new Ibrahimia regulator

Figure 2-2.58 Result of the riverbed variation analysis (planning stage)

b) Evaluation

From the analysis of riverbed variation, the following statements can be made.

1) New Bahr Yusef regulator

There is the possibility of local scouring directly downstream of the new Bahr Yusef regulator.

2) New Ibrahimia regulator

There is the possibility of local scouring directly downstream, as well as slight deposition directly upstream of the new Ibrahimia regulator.

3) New Abo Gabal regulator and new Sahelyia regulator

Regardless of the existence of the new regulators, there is a possibility of deposition occurring on the left bank side upstream of the existing Abo Gabal regulator, in the upper reaches of the Ibrahimia canal, and in front of the Sahelyia regulator. However, the new Abo Gabal and Sahelyia regulators jut out the existing canal banks, which is reducing the slow-flowing area on upstream area of the existing regulators and the amount of deposition in front of the new small regulators compared with the present conditions. From this, it is assumed that there is less impact on intake.

Interpretation on the riverbed change in front of the central part of DGRs at calibration stage

Figure 2-2.54 titled "Result of the riverbed variation analysis (calibration stage)," takes the data surveyed between November 2015 and January 2016 as the reference data of the calibration, which indicates that more sedimentation occurs than previously considered.

The captioned area is supposed to display reverse sedimentation/erosion. The natural assumption was that the sedimentation in the area was the result of natural deposition that occurred from November 2015 to January 2016. The calculation results at the calibration stage also showed sedimentation patterns in the area, even though its extent was different. This means that actual survey results and calculated results are generally matched.

This reverse phenomenon was observed because most of the excavation work was carried out during the survey period (the beginning of January 2016), when there was no data collected on the excavated area. This problem made the evaluation much harder because the reason for the change in bed level remained unknown. Therefore, no evaluation of bed transport can be made in the design of NDGRs.

However, a model has been constructed that can show future trends in bed level changes. This model was built based on all the available data during the project period, even without data on actual sediment discharge volume, and actual particle size distribution.

In the future, to improve the accuracy of the model, more detailed topographical data and time series data of flow discharge, water level, and the operating state of each canal regulator are required.

3. Integrated Evaluation of Hydraulic Model Test

3-1 Purpose of integrated evaluation of hydraulic model test

The objective of the integrated evaluation was to provide the information and advice on the hydraulic model experiments that were entrusted by MWRI to the HRI in order to establish the consistency with the numerical simulation implemented in this project. At first, the hydraulic model test was limited to the 3D hydraulic model test that covered the surrounding area of the DGRs, but the 2D hydraulic model test of one of the new Bahr Yusef regulator, mainly for the bed protection work was added independently. The integrated evaluation was made based on these two tests.

3-2 Monitoring of 3D model test

(1) Provision of the results of survey on the natural conditions

A meeting with HRI was held together with RGBS to provide the results of the topographic survey and geological survey carried out in this Study as the basic data for the physical hydraulic model test.

As a result, it was confirmed that HRI had already completed the topographic survey for the physical hydraulic model test and that no further results of the survey were required in this Study.

As for the specifications and drawings for the new regulator design to be used in the hydraulic model tests, it was confirmed that for the model specifications of the new regulators for the hydraulic model tests, those used in the past F/S period were used because the work processes of the hydraulic model tests were scheduled to be completed in February 2016, earlier than the completion time of the basic design of the new regulators (July 2016).

The implementation process of the hydraulic model test at the start of this study and the new regulator design schedule in this Study are shown below (see Table 3-2.1 and Table 3-2.2.).

The additional hydraulic model test is currently on going and the final report has not been submitted yet. And additional hydraulic model test is not subject to integrated evaluation by D/D consultants.

Table 3-2.1 Work schedule of physical hydraulic model test

(Conducted for 10 months from May 2015 to February 2016)

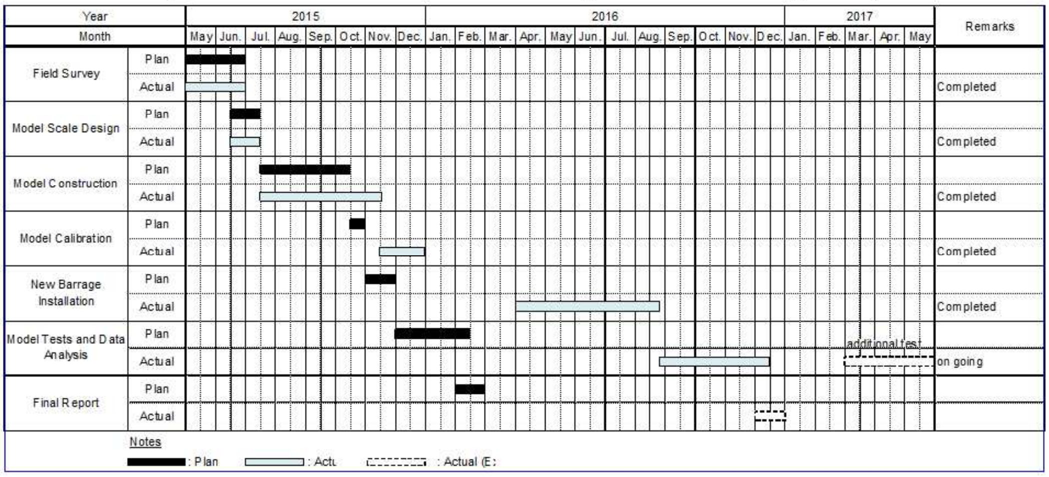
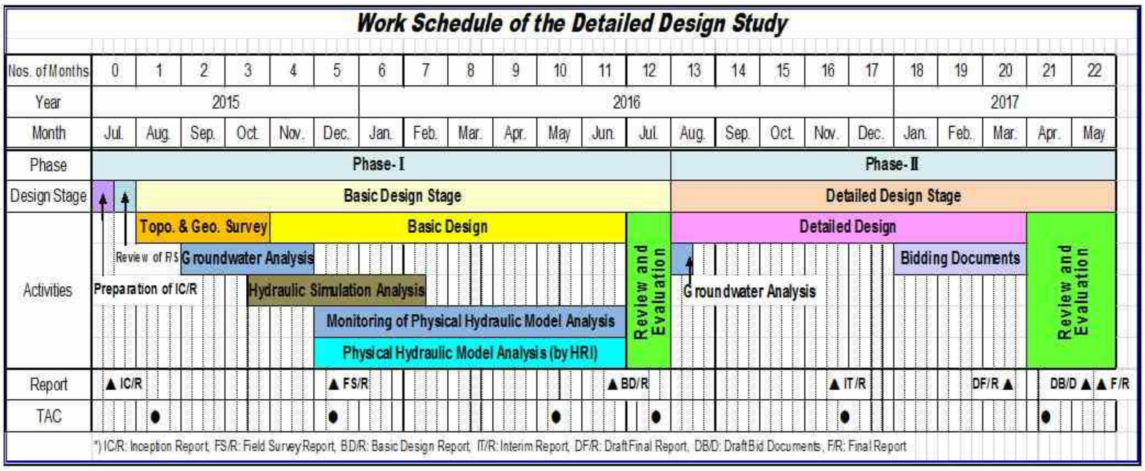


Table 3-2.2 Work schedule of this study

(The hydraulic model tests were conducted for 7 months from December 2015 to June 2016.)



Work Schedule of the Detailed Design Study

Nos. of Months	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Year	2015						2016												2017				
Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Phase	Phase-I													Phase-II									
Design Stage		Basic Design Stage												Detailed Design Stage									
Activities		Topo. & Geo. Survey		Basic Design									Review and Evaluation	Detailed Design								Review and Evaluation	
	Review of FS		Groundwater Analysis																Bidding Documents				
	Preparation of IC/R			Hydraulic Simulation Analysis										Groundwater Analysis									
						Monitoring of Physical Hydraulic Model Analysis																	
						Physical Hydraulic Model Analysis (by HRI)																	
Report	▲ IC/R					▲ FS/R						▲ BD/R					▲ IT/R				DF/R ▲	DB/D ▲	▲ F/R
TAC		●				●					●		●				●					●	

*) IC/R: Inception Report, FS/R: Field Survey Report, BD/R: Basic Design Report, IT/R: Interim Report, DF/R: Draft Final Report, DB/D: Draft Bid Documents, F/R: Final Report

(1) Monitoring and advice

In the respective stages of processes of the hydraulic model test schedule (test plan, model production, test measurements and phenomenon analysis), the details, method and conditions of each test were confirmed in Egypt.

The field survey for the hydraulic model tests had been carried out by HRI before the start of this Study (at the end of July 2015).

On monitoring the hydraulic model tests, the reports (drafts) were received at the following times:

August 2015	Field Investigation Report (Field Investigation at Dairut Group of Regulators for Physical Model Studies)
October 2015	Progress Report 2 (Physical Model Study of Dairut Group of Regulators Progress Report No.2 Model Design and Construction)
February 2016	Progress Report 3 (Physical Model Study of Dairut Group of Regulators Progress Report No.3 Model Set-up and Calibration)
December 2016	Draft Report (Physical Model Study of Dairut Group of Regulators Installation of the New Dirout Regulators and Flow Velocity Measurements)

The monitoring records on hydraulic model test are shown below.

Table 3-2.3 Monitoring records on hydraulic model test

No.	Date		Activity
1	4	2015 August	Monitoring the plan of installing the facility to perform hydraulic model test
2	19	October	Monitoring the construction status of the existing facility
3	27	October	Same as above
4	23	November	Monitoring the installation status of the existing facility
5	26	November	Same as above
6	29	November	Monitoring the flow pre-test for the existing facility
7	22	December	Monitoring the calibration test for the existing facility
8	1	2016 February	Same as above
9	25	February	Same as above
10	13	April	Same as above
11	29	June	Monitoring the construction status of the planned facility
12	31	July	Monitoring the installment conditions of the planned facility
13	2	August	Same as above
14	9	August	Same as above
15	23	August	Monitoring the flow pre-test for the planned facility
16	20	October	Monitoring the flow test for the planned facility and the installation status of the 2D hydraulic model test facility
17	22	2017 February	Monitoring the flow test for the planned facility and 2D hydraulic model test facility

a) Test plan

The D/D consultant visited HRI in August 2015 and had a meeting on the test plan of the hydraulic model test. Then, the site for installing the test laboratory and the field for physical hydraulic model construction were confirmed.

The scale of the hydraulic model test facility was determined to be 1/25 based on the size of the installation site and the supply capacity of flow discharge to be applied at the facility.

The purposes of hydraulic model test, the facility layout plan, the test conditions, the test cases and the similarity rules will be described below.

a-1) Purpose of test

The purpose of performing physical hydraulic model test is as follows:

> "The focal objective of the testing program is to adopt the best alignment and hydraulic design for the new barrages group components which fulfills the new emerged flow morphology regime through El-Ibrahimia canal after the construction of the new Assuit barrages. Flow capacity and velocity distribution upstream and downstream each of the new group components would be physically tested and investigated."

Source: Progress Report 3 (Physical Model Study of Dairut Group of Regulators Progress Report No.3 Model Set-up and Calibration)

a-2) Test device

Due to the restrictions of the HRI facility, the device for physical hydraulic model test was designed to be in the scale of 1/25 in both horizontal and vertical directions, and it was installed in the range of 46 m in the upstream and downstream directions and 24 m across. The actual scale of the site is approx. 1,150 m in the upstream and downstream directions and approx. 600 m across.

The test device has an underground reservoir weir and the discharge volume to the canal end is gathered in the underground reservoir tank, so that water is pumped up at the upstream end and discharged to the upstream end of the canal for cyclic use. The discharge from the upstream end of the canal is measured by the ultrasonic flow meter installed at the pipeline and the discharge to the downstream end of each canal is measured by the overflow depth in each regulator.

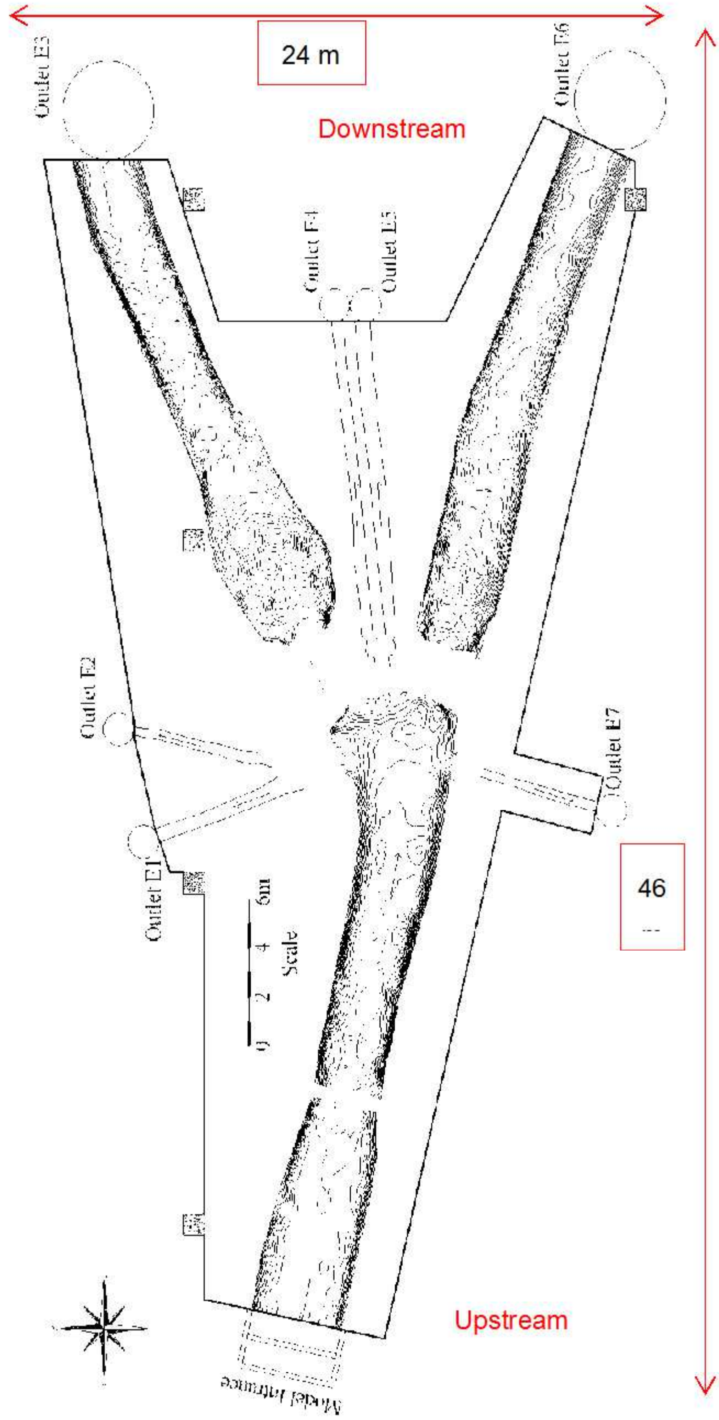


Figure (24): General Layout of the Modelled Reach

Figure 3-2.1 Plan for hydraulic model test

Source: Progress Report 2 (Physical Model Study of Dairut Group of Regulators Progress Report No.2 Model Design and Construction)

a-3) Similarity rules

This physical hydraulic model test targets the flow in the canal with the free water surface; as such, the flow is dominated mainly by gravity and inertia. Therefore, Froude's similarity rules are applicable to the flow.

The hydraulic model facility is designed at the scale of 1/25 in all the directions. The similarity rules for each hydraulic quantity are shown in Table 3-2.4 below.

Table 3-2.4 Similarity rules

Hydraulic Quantity	Units	Scale	Model
Length/ Depth	m	$n_L = n_{model}/n_{prototype}$	1/25
Area	m^2	$n_A = n_L^2$	1/625
Flow velocity	m/s	$n_V = n_L^{1/2}$	1/5
Discharge	m^3/s	$n_Q = n_L^{5/2}$	1/3125

b) Measurement items in the test

The measurement items in the physical hydraulic model test are shown below.

b-1) Discharge

) Inflow

The flow from the upstream reach of the physical hydraulic model test device is pumped up and supplied from the underground reservoir tank of the device into the pipeline. For this reason, the flow is measured by an ultrasonic flow meter installed in the pipeline.

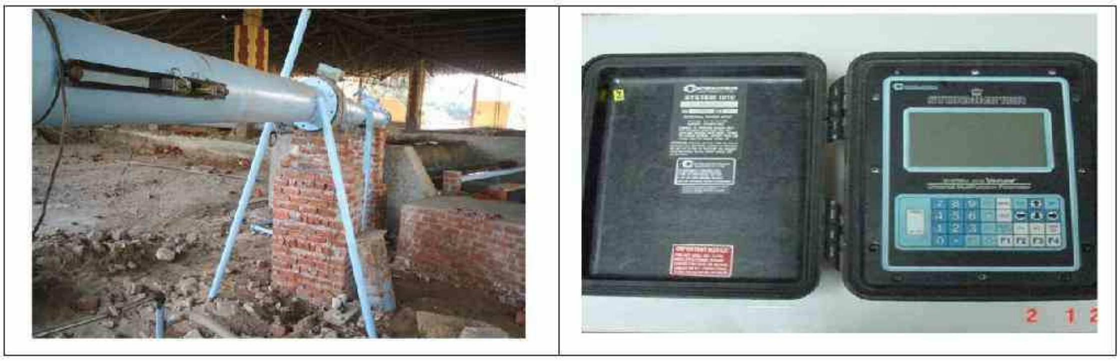


Figure 3-2.2 Inflow measuring equipment (ultrasonic flow meter)

) Outflow

The inflow at the downstream end of the physical hydraulic model test facility is measured by installing an overflow regulator sharp crested weir.

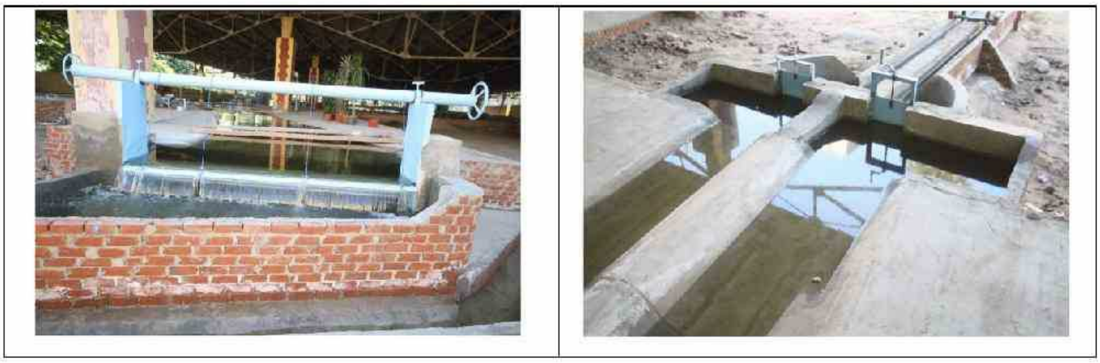


Figure 3-2.3 Discharge measuring device (regulator)

b-2) Water level

The water level is measured by the point gauge installed on the canal survey line as the criterion for the water level and flow measurements in the field survey. The accuracy is 0.1 mm for the model and 0.25 cm for the prototype.

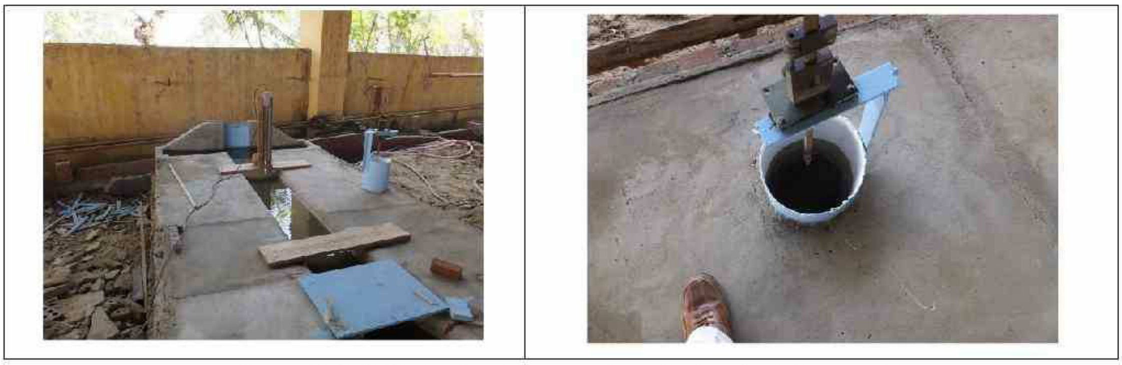


Figure 3-2.4 Water level measuring device (point gauge)

b-3) Flow velocity

The flow velocity can be measured at an arbitrary water depth on an arbitrary survey line by the use of a micro current meter. The average flow velocity within a measuring time is calculated and indicated on the meter.

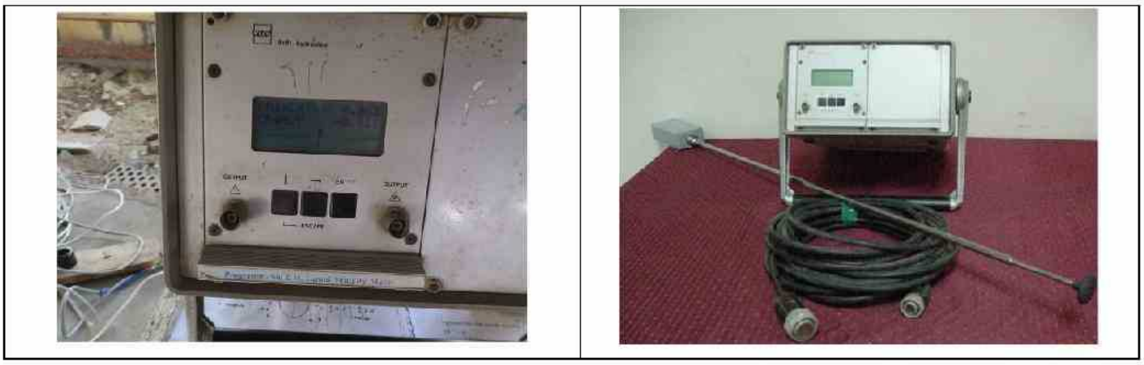


Figure 3-2.5 Flow velocity measuring equipment (micro current meter)

b-4) Test Case

The 3D physical hydraulic model test was carried out in two test cases as described below:

Calibration Stage: In this case, the existing water canal and facility were modelled to reproduce the flow by using the test device.

Planning Stage: In this case, the planned equipment was installed to monitor the upstream and downstream conditions of the new regulators at the maximum discharge, the dominant discharge and the minimum discharge.

Table 3-2.5 Physical hydraulic model test cases

Test Case	Upstream of Existing Regulators			Target Facility	Navigation Lock		Remarks
	Discharge (m^3/s)		Water level (EL. m)		Bahr-Yusef	Ibrahimia	
Calibration	Measured	355	46.02	Existing Regulator	Open	Closed	-
Planning	Maximum	455	46.30	New Regulators	Open	Closed*	-
	Dominant	306					-
	Minimum	22.67					-

Note*: The latest hydraulic model test will be carried out under conditions that opened the navigation lock.

c) Monitoring and advice

c-1) Calibration Stage

The calibration stage is described in the "Interim Report 3 at Calibration Stage" as follows:

Model calibration is the process for judging reliability and consistency between the constructed model and prototype condition. In order to ensure that, the model should fulfill the geometric, kinematic and dynamic similarity conditions. The geometric similarity was already applied during the model construction. The kinematic and dynamic similarity would be accomplished by measuring some flow velocity profiles in the prototype then compared it with that in the model. Therefore, the model calibration should include all the above mentioned conditions in addition the water surface slope which should be the same in the model as prototype value.

The three dimensions "DGR" model would be calibrated with bathymetric and hydraulic measurements and flow conditions that carried out during "HRI" field investigations which were conducted on June 2015. The model was calibrated against one cross section velocity profile along each of the seven branched canals downstream of the existing "DGR". The flow discharge in the model and accordingly through each branched canal were worked out according to the flow condition during field measurements. The water surface slope through the seven branched canals was also measured during the field measurements which ranged between 4.30 cm/km for Irad Delgaw canal and 8.9 cm/km for El-Dairutia canal. Applying the above mentioned procedure for operating the model, the calibration process was carried out through the following three phases:

- Inflow discharge calibration
- Establishing calibration condition
- Velocity measurement calibration

c-1-1) Water-level and discharge conditions

The observed values obtained in the measurements on June 30, 2015, are applied to the water-level discharge conditions in the calibration stage. The conditions for the upstream point of the existing DGRs were: the water level of EL. 46.02 m and the discharge of 355 m^3/s. The water level and discharge on the downstream side of each regulator were calibrated so that both values are equal to the measured water level and discharge.

Water level and discharge on the downstream side of each regulator are shown in Table 3-2.6.

Table 3-2.6 List of water level and discharge conditions in calibration stage

Item	US. of Regulators	DS. of Regulators							Remarks
	Existing DGRs	Bahr Yusef	Ibrahimia	Badraman	Diroutiah	Abo Gabal	Irad Delgaw	Sahelyia	
Water Level (m)	46.02	45.82	45.05	45.68	45.88	45.73	44.79	45.72	
Inflow (m^3/s)	355.0	–	–	–	–	–	–	–	
Outflow (m^3/s)	–	170.6	157.3	6.1	9.2	6.1	2.2	3.1	

c-1-2) Model manufacture

The D/D consultant visited the HRI site to inspect the model construction site for the existing regulators and confirmed that the model was being produced under the measured conditions. Also, the D/D consultant visited the installation site of the adjacent hydraulic model test facility and confirmed that respective channel forms for each survey section were installed according to the canal frames at a given altitudes, as well as the way canal construction is conducted with mortar.

The scenes of confirming the production of the existing regulators and canals are shown below.

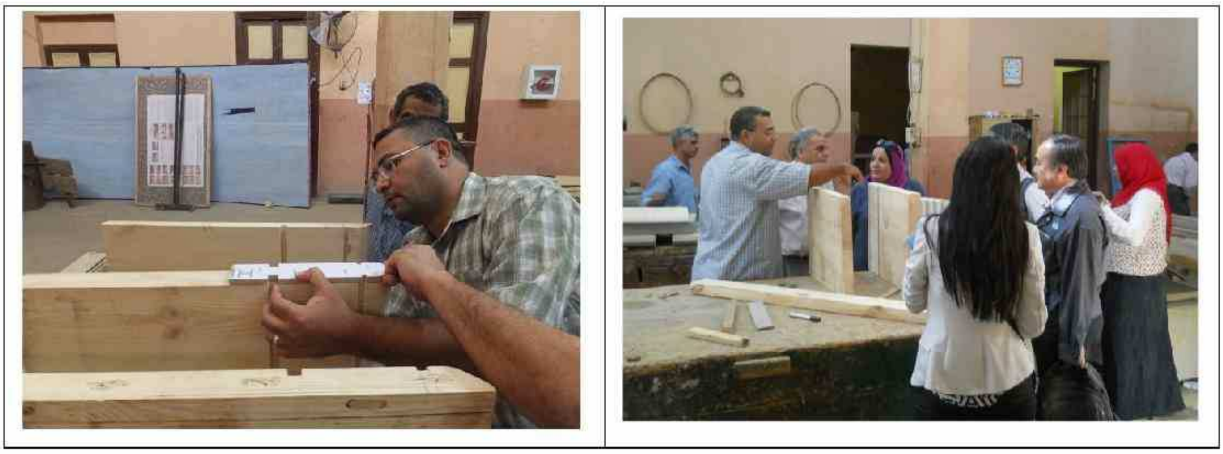


Figure 3-2.6 Scenes of constructing of existing regulators (small scale regulator pier)

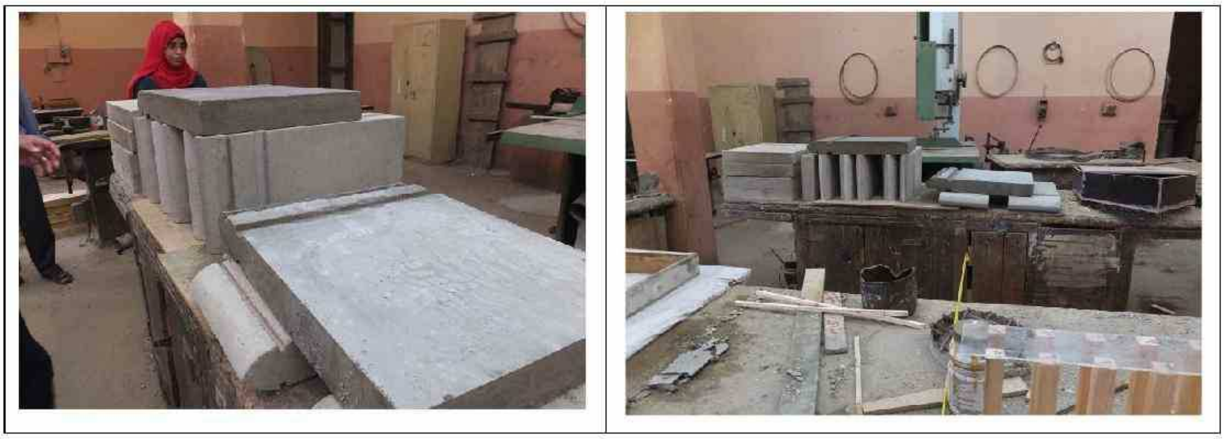


Figure 3-2.7 Scenes of constructing of existing regulators (large scale regulator pier)

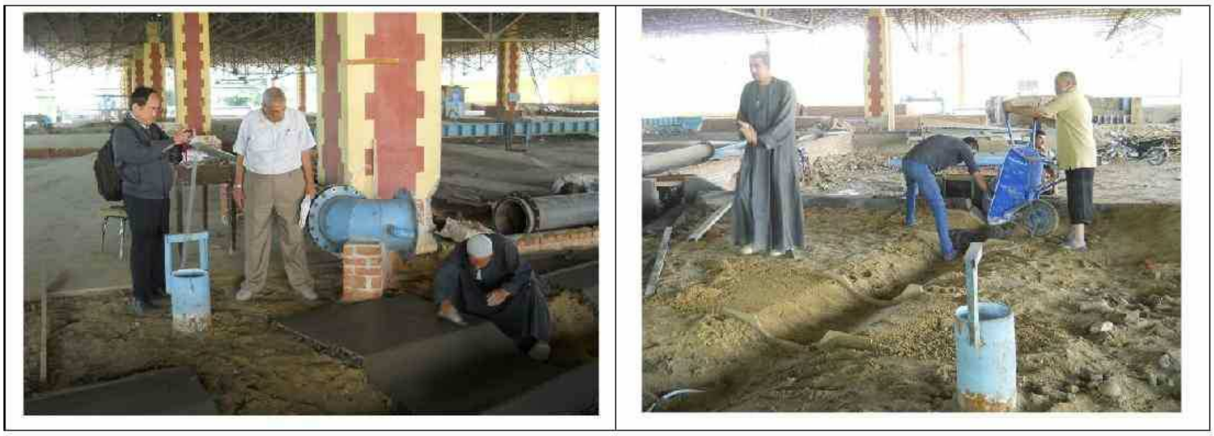


Figure 3-2.8 Scenes of constructing existing canals (using mortar)

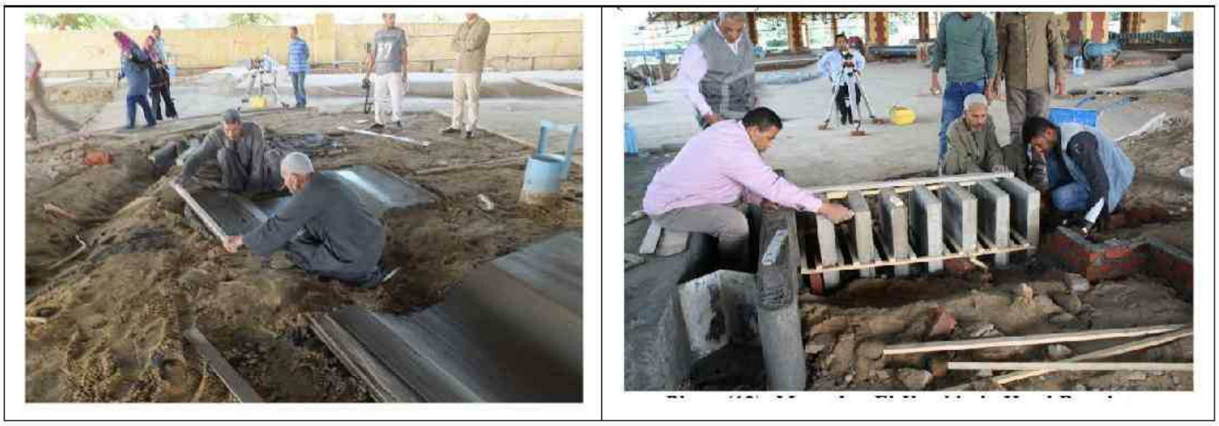


Figure 3-2.9 Scenes of manufacture of existing canals
(Existing canal construction and large-scale regulators)

c-1-3) Test measurements

The measurements in the physical hydraulic model test were performed at the calibration stage.

In the physical hydraulic model test, the water level was measured by a point gauge and the flow velocity by a micro current meter in the same position as in the cross section in the prototype.

The results in the calibration stage made clear that the model could reproduce the actual conditions of the prototype.

The achieved calibration results that illustrated in the above Tables and Figures revealed that the measured mid –depth velocity profiles in the model are following the same trend as that in the prototype. This in other words means that there are good agreement between the model and prototype and the model can be accurately simulate the prototype conditions.

Source: Progress Report 3 (Physical Model Study of Dairut Group of Regulators Progress Report No.3 Model Set-up and Calibration)

During the on-site confirmation at the calibration stage, RGBS requested advice on the physical hydraulic model test, and the D/D consultant recommended that the flow velocity measurements be made at the downstream points of 30 m, 50 m and 100 m from the new Bahr Yusef and Ibrahimia regulators for comparison with the results of hydraulic analysis.

Table 3-2.7 Conditions of calibration stage

Test Case	Upstream of Existing Regulators			Target Facility	Navigation Locks		Remarks
	Discharge (m3/s)		Water level (EL. m)		Bahr-Yusef	Ibrahimia	
Calibration Stage	Actual Discharge	355	46.02	Existing Regulators	Closed	Closed	

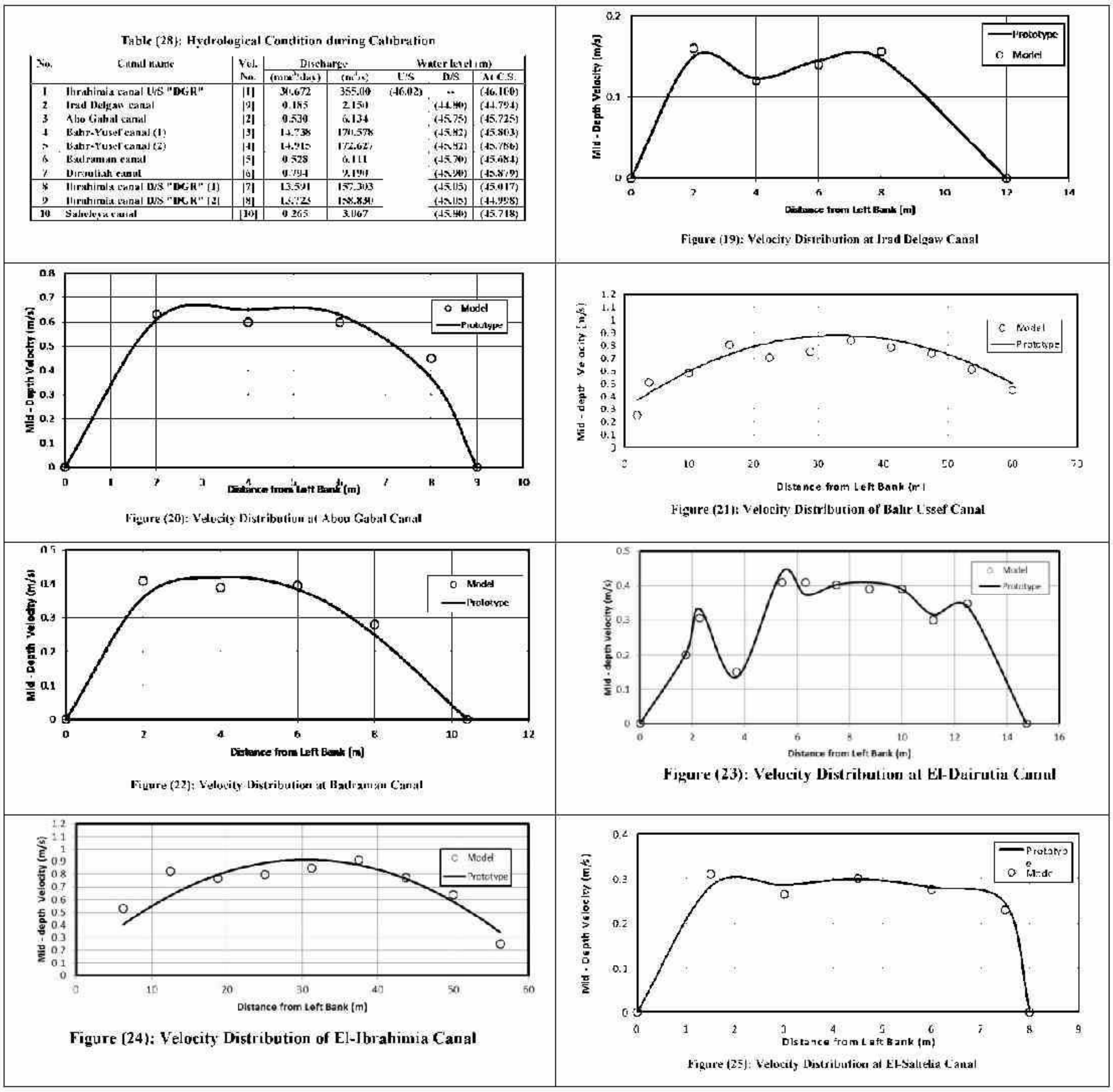


Table (28): Hydrological Condition during Calibration

No.	Canal name	Vel. No.	Discharge (mm^3/day)	Discharge (m^3/s)	Water level (m) U/S	Water level (m) D/S	Water level (m) At C.S.
1	Ibrahimia canal U/S "DGR"	[1]	30.672	355.00	(46.02)	--	(46.100)
2	Irad Delgaw canal	[9]	0.185	2.150		(44.90)	(44.794)
3	Abo Gabal canal	[2]	0.530	6.134		(45.75)	(45.725)
4	Bahr-Yusef canal (1)	[3]	14.738	170.578		(45.82)	(45.803)
5	Bahr-Yusef canal (2)	[4]	14.915	172.627		(45.82)	(45.786)
6	Badraman canal	[5]	0.528	6.111		(45.70)	(45.684)
7	Dirouliah canal	[6]	0.794	9.199		(45.90)	(45.879)
8	Ibrahimia canal D/S "DGR" (1)	[7]	13.591	157.303		(45.05)	(45.017)
9	Ibrahimia canal D/S "DGR" (2)	[8]	13.723	158.830		(45.05)	(44.998)
10	Saheleya canal	[10]	0.265	3.067		(45.90)	(45.718)

Figure (19): Velocity Distribution at Irad Delgaw Canal

Figure (20): Velocity Distribution at Abou Gabal Canal

Figure (21): Velocity Distribution of Bahr Usef Canal

Figure (22): Velocity Distribution at Badraman Canal

Figure (23): Velocity Distribution at El-Dairutia Canal

Figure (24): Velocity Distribution of El-Ibrahimia Canal

Figure (25): Velocity Distribution at El-Saheleia Canal

Figure 3-2.10 Results of cross-sectional flow velocity distribution

Source: Interim Report on Calibration Stage

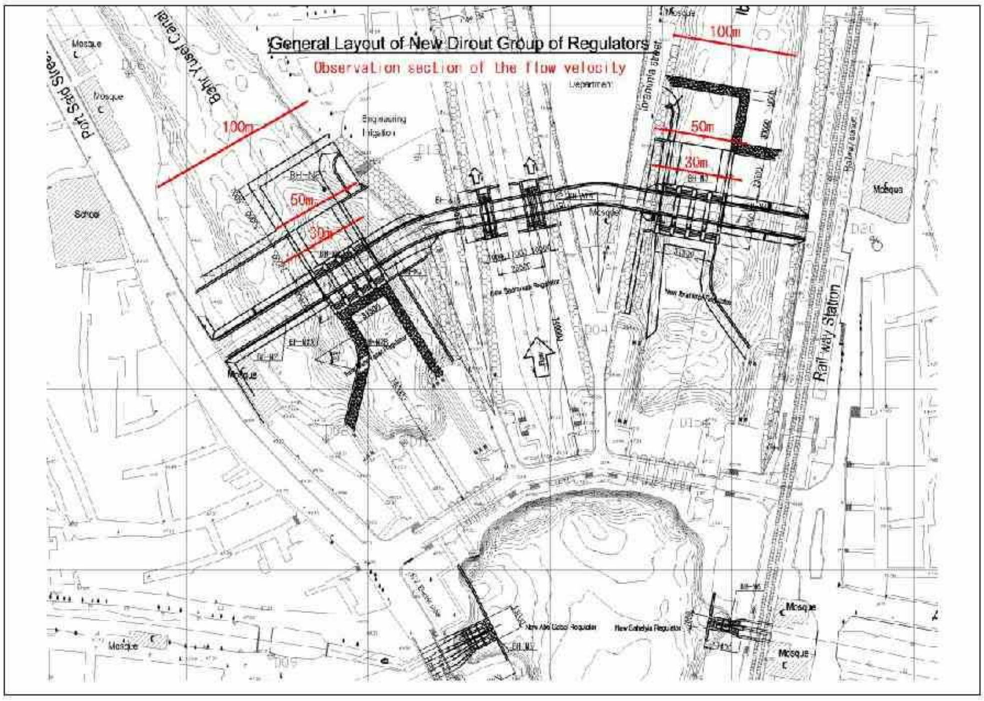


Figure 3-2.11 Observation section of the cross-sectional flow velocity on the downstream of the NDGRs

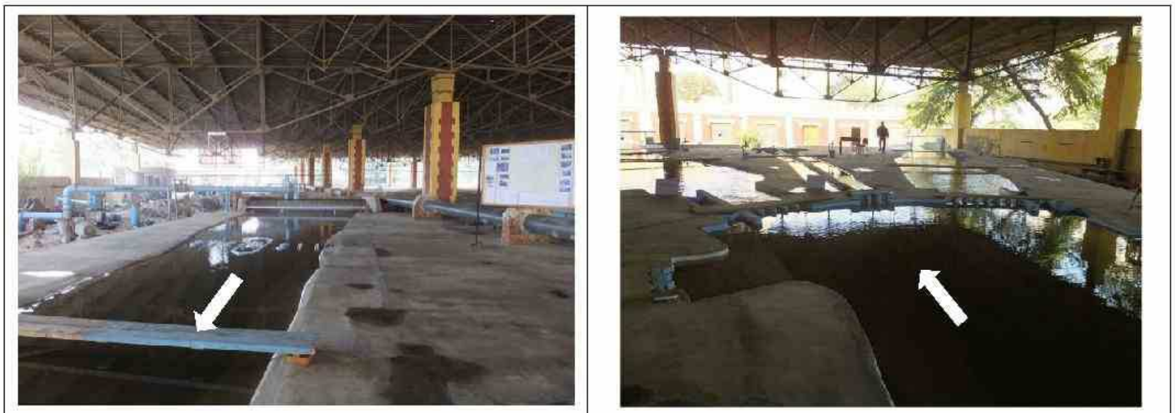
c-1-4) Analysis of phenomena

The D/D consultant observed and evaluated the flow conditions in the physical hydraulic model tests in the calibration stage for the phenomenon analysis.

In the calibration stage, it was confirmed that the flow in the upstream reach of the existing regulators was regulated in the physical hydraulic model test facility and was the same condition as in the field.

On the downstream side of the existing Bahr Yusef regulator and the Ibrahimia regulator, it was confirmed that some turbulence was generated in the flows in the same manner as in the field.

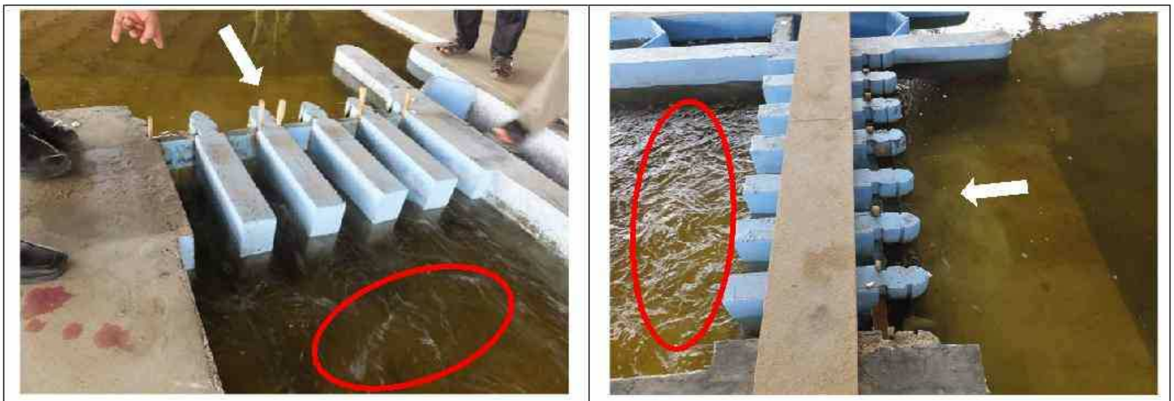
It was also confirmed that some vortexes were generated in the dead water region on the both downstream banks of the regulators. These were the phenomena that were confirmed in the field. Therefore, the physical hydraulic model test facility was evaluated as a facility that could reproduce those phenomena.



Upstream side of existing regulators

Upstream side of existing regulators

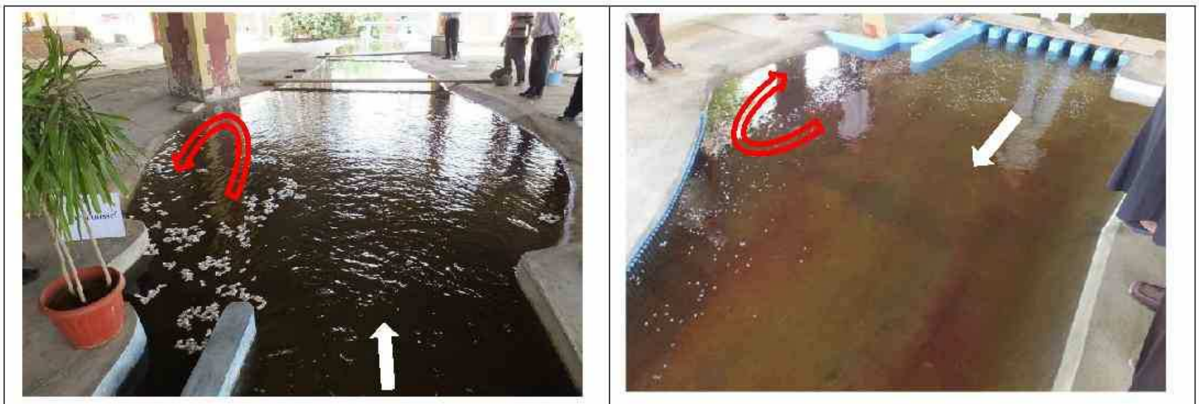
Figure 3-2.12 Flow situation on the upstream side of existing regulators in calibration stage (gentle flow)



Downstream side of existing Bahr Yusef regulators

Downstream side of existing Ibrahimia regulators

Figure 3-2.13 Flow situation on downstream side of existing regulators in calibration stage (turbulent flow)



Downstream side of existing Bahar Yusef regulators

Downstream side of existing Ibrahimia regulators

Figure 3-2.14 Flows on downstream side of existing regulators in calibration stage (dead water region)

It was confirmed that there were canals in which blocks were laid on the upper stream of the calibration survey line to increase their roughness. As the adjustment range for this calibration covered up to the downstream reach close to the planned point of installing the new regulators, DD consultant pointed out that in the planning stage it would be necessary to take the flow situation into consideration.

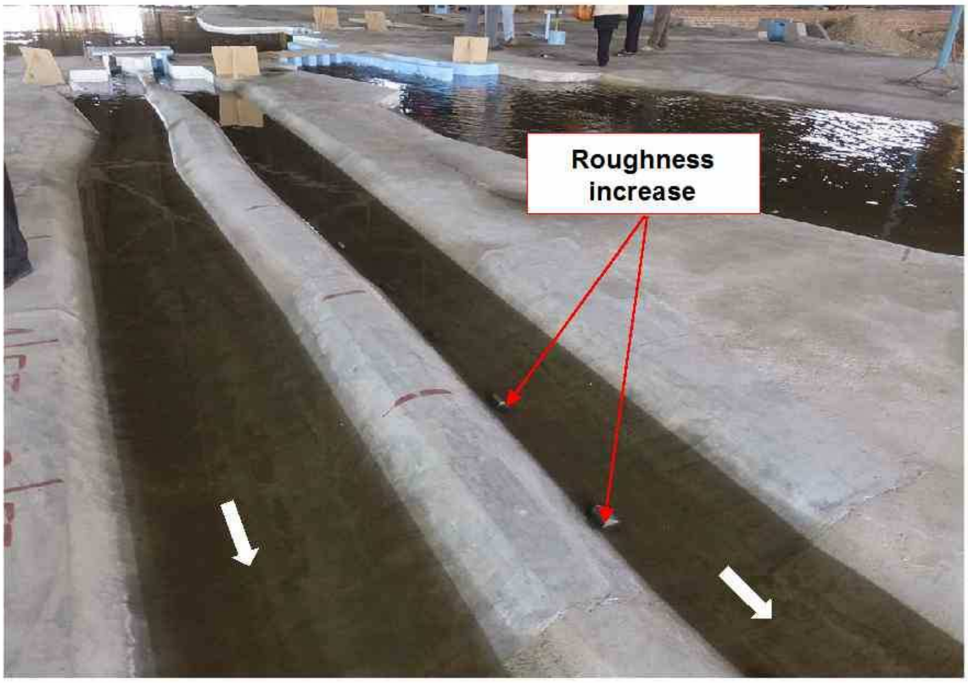


Figure 3-2.15 Increasing roughness on the downstream side of existing regulators (laying blocks)

c-2) Planning stage

c-2-1) Water-level discharge conditions

For the maximum discharge in the planning stage, the design discharge is 455 m^3/s, and the design control water level is EL. 46.30 m on the upstream side of the DGRs. The downstream water level and discharges of each regulator are those in the design conditions as shown in Table 3-2.8.

The water-level and discharge conditions for the dominant discharge and the minimum discharge are shown in Table 3-2.8.

Table 3-2.8 List of water level and discharge conditions in planning stage

Case	Item	US. of Regulators	DS. of Regulators							Remarks
		Existing DGRs	Bahr Yusef	Ibrahimia	Badraman	Diroutiah	Abo Gabal	Irad Delgaw	Sahelyia	
Maximum Discharge	Water Level (m)	46.30	45.60 (45.82)	45.15 (45.13)	45.85 (45.90)	45.85 (45.90)	45.85 (45.90)	45.00 (45.90)	45.85 (45.90)	( ) Target WL
	Inflow (m^3/s)	455	–	–	–	–	–	–	–	
	Outflow (m^3/s)	–	227	186	9	12	7	9	5	
Dominant Discharge	Water Level (m)	46.30	45.30	44.50	45.60	45.60	45.60	44.60	45.65	
	Inflow (m^3/s)	306.644	–	–	–	–	–	–	–	
	Outflow (m^3/s)	–	162.523	115.984	5.938	8.380	4.444	6.470	3.021	
Minimum Discharge	Water Level (m)	46.30	52.55	41.55	–	–	–	–	–	
	Inflow (m^3/s)	22.67	–	–	–	–	–	–	–	
	Outflow (m^3/s)	–	18.52	2.08	0.44	0.63	0.32	0.46	0.22	

c-2-2) Model manufacture

Through the discussions with RGBS, it was decided to substantially change the scale of the new regulators in the F/S period. It was determined to provide the dimensions and drawings to RGBS as soon as the regulator design in the basic design stage is completed.

The drawings in the basic design stage were provided to RGBS at the end of April 2016. HRI produced the new regulator models based on those drawings provided by RGBS and installed them during the early part of August 2016.

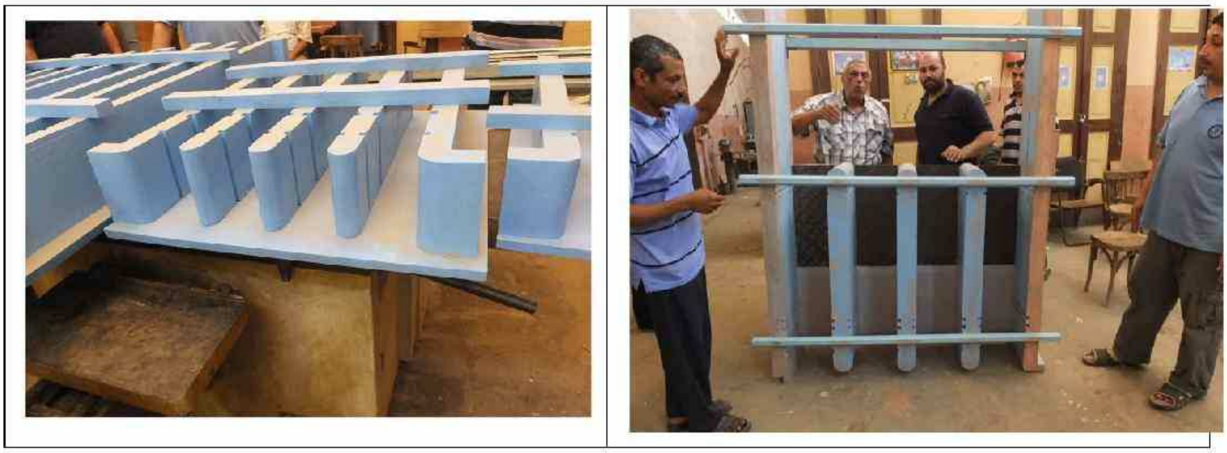
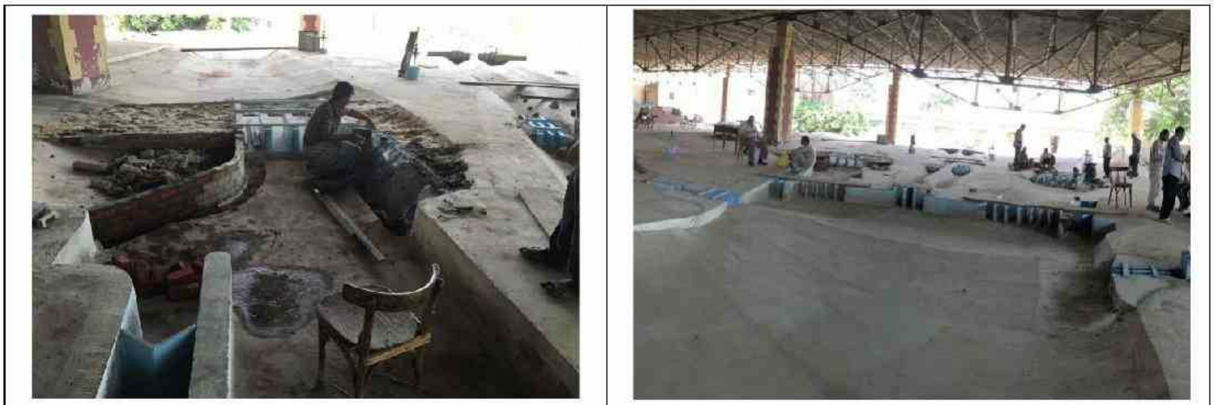


Figure 3-2.16 Scenes of construction of new regulators (large scale regulators)



Installation of new Bahr Yusef regulators

Upstream end of existing regulators

Figure 3-2.17 Installation of new regulators at test site

After completion of the basic design, in late August 2016, RGBS requested the D/D consultant to change the foundation height of 2 upstream small-scale regulators and the change of the foundation height was determined in September 2016. However, the models had been installed at the foundation height as designed in the basic design stage. Therefore, it was decided to perform the physical hydraulic model tests as specified before the change of foundation height.

c-2-3) Test measurements

The measurements in the physical hydraulic model test were conducted in the planning stage.

The flow velocity was measured by a micro current meter at the points of 30 m, 50 m and 100 m downstream from the regulator axes of the new Bahr Yusef regulator and the new Ibrahimia regulator.

Table (9): Absolute Values of the Flow Velocities at Sections downstream of the New Large Regulators for the Over flow and Underflow Conditions

Sec.	Canal	Over Flow									Under Flow		
		Maximum Discharge			Dominant Discharge			Minimum Discharge			Maximum Discharge		
		V_{max}- (m/s)	V_{min}- (m/s)	V_{ave}- (m/s)	V_{max} (m/s)	V_{min}- (m/s)	V_{ave}- (m/s)	V_{max} (m/s)	V_{min}- (m/s)	V_{ave}- (m/s)	V_{max} (m/s)	V_{min}- (m/s)	V_{ave}- (m/s)
Sec. 1	Ibrahimia	2.60	0.50	1.55	1.80	0.28	1.05	0.28	0.01	0.14	2.80	0.60	1.70
	Bahr Yusef	1.20	0.20	0.70	0.57	0.02	0.30	0.28	0.02	0.15	2.52	0.89	1.70
Sec. 2	Ibrahimia	1.75	0.02	0.88	1.04	0.02	0.52	0.18	0.01	0.09	1.33	0.03	0.66
	Bahr Yusef	1.43	0.02	0.72	1.20	0.05	0.62	0.43	0.01	0.22	1.50	0.05	0.75
Sec. 3	Ibrahimia	1.05	0.07	0.53	0.82	0.04	0.43	0.27	0.07	0.14	0.90	0.03	0.46
	Bahr Yusef	1.12	0.02	0.56	0.96	0.16	0.56	0.266	0.07	0.16	1.08	0.06	0.57

Sec.1
30 m

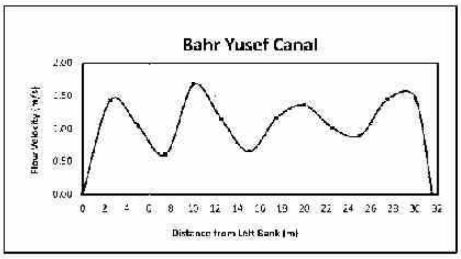


Figure (3): Flow Velocity Distribution at Mid Depth of Cross Section 1

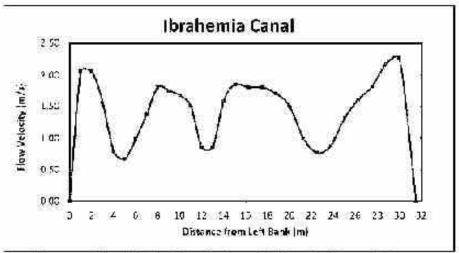


Figure (1): Flow Velocity Distribution at Mid Depth of Cross Section 1

Sec.2
50 m

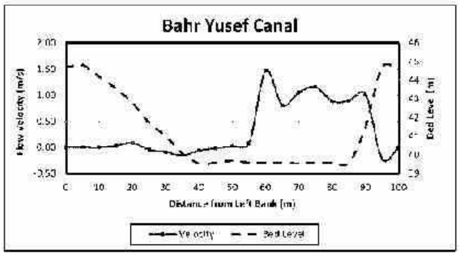


Figure (3): Flow Velocity Distribution at Mid Depth of Cross Section 2

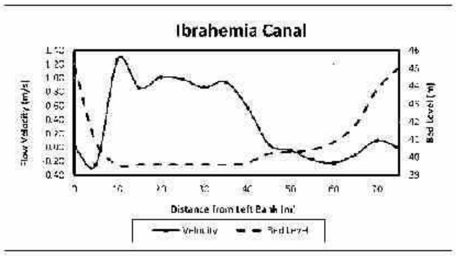


Figure (1): Flow Velocity Distribution at Mid Depth of Cross Section 2

Sec.3
100
m

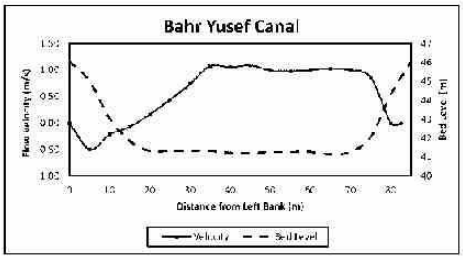


Figure (3): Flow Velocity Distribution at Mid Depth of Cross Section 3

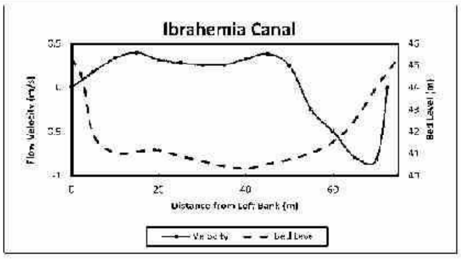


Figure (1): Flow Velocity Distribution at Mid Depth of Cross Section 3

Figure 3-2.18 Measured results of cross-sectional flow velocities

Source: Report (Draft) (3D Model)

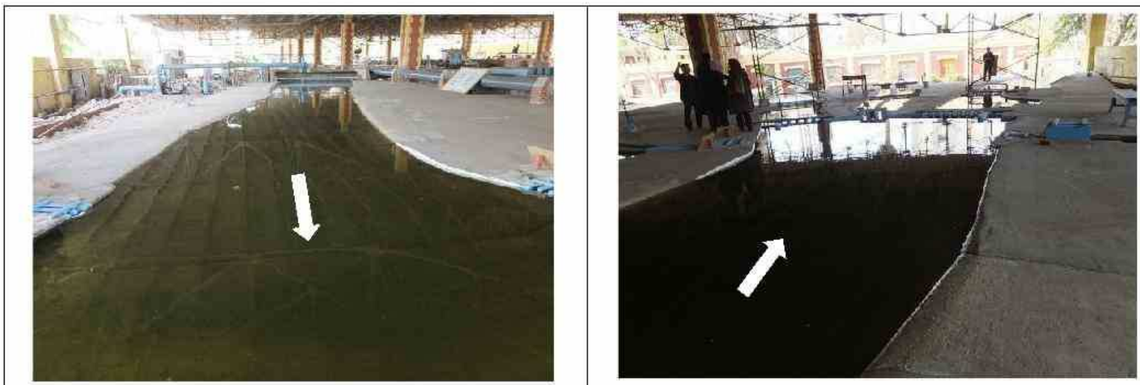
c-2-4) Analysis of phenomena

In the planning stage, the new regulators were installed at 140 m downstream from the bridge end of the existing regulator group.

It was confirmed that the upstream flow of the DGRs in the physical hydraulic model test facility was smooth. (see Figure 3-2.19.)

It was confirmed that some turbulence in the discharge flow was generated on the downstream side of the new Bahr Yusef and the new Ibrahimia regulators. (see Figure 3-2.20.)

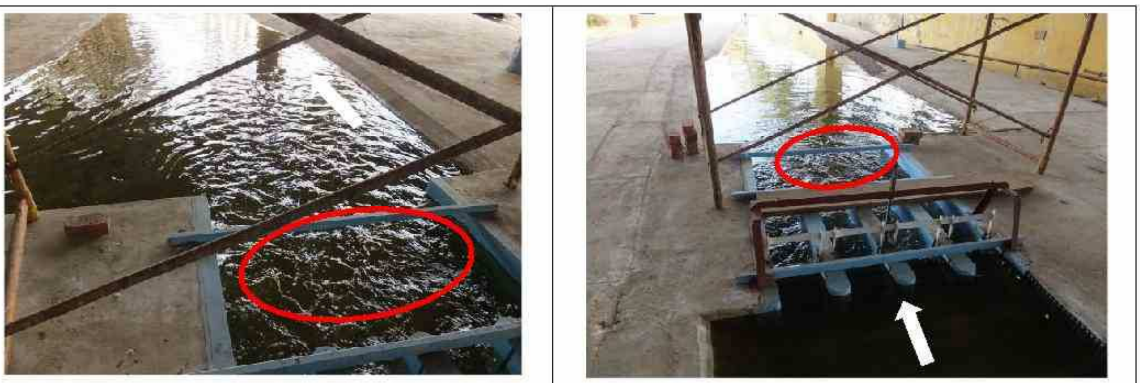
It was also confirmed that some vortexes were generated in the dead water region on the downstream side of the new regulators. (see Figure 3-2.21.)



Upstream side of existing regulators

Upstream side of existing regulators

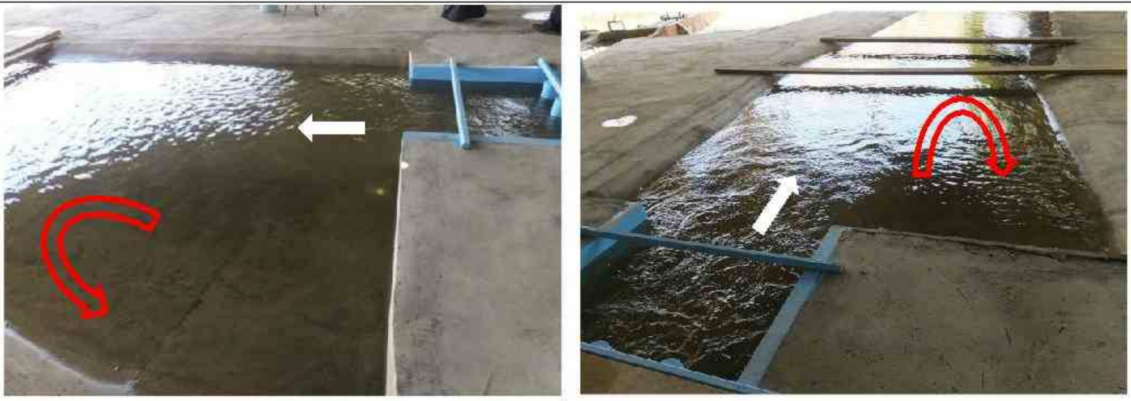
Figure 3-2.19 Upstream flow situation of new regulators in planning stage (gentle flow)



Downstream side of new Bahr Yusef regulators

Downstream side of new Ibrahimia regulators

Figure 3-2.20 Downstream flow situation of existing regulators in planning stage (turbulent flow)



Downstream side of new Bahr Yusef regulator

Downstream side of new Ibrahimia regulator

Figure 3-2.21 Downstream flow situation of existing regulators in planning stage

3-3 Monitoring of 2D physical hydraulic model test

(1) Test Plan

The 2D physical hydraulic model test was carried out to reproduce the hydraulic jump phenomenon in the lower stream of the gates and to test the riverbed protection. Initially, this test was not planned.

The D/D consultant received the following report draft:

February 2017..................Report Draft (2D model of the new Bahr Yusef regulator)

a) Objectives of test

The objectives of the 2D physical hydraulic model test are as described below.

> “The objectives of the 2D physical model can be summarized as follows:
> - Study the flow characteristics along the stilling basin including formation of hydraulic jump.
> - Optimize the stilling basin dimensions based on the typed intensity of hydraulic jump.
> - Check the head losses due to the construction of new Bahr Yousef regulator with fully open gates.
> - Investigate the stability of the rip-rap protection layer downstream the apron.”

Source: Report Draft (2D Model)

b) Test device

The test device is described in the “Report Draft (2D Model)” as follows:

> A 2D model with an undistorted scale 1:8.5 was designed to simulate one bay of Bahr Yousef regulator, the stilling basin, the rip- rap in both upstream and downstream reaches. The model structure is made from Plexiglas material in a steel-framed glass walled flume of 26.0 m long and 1.0 m wide, and 1.2 m high. The model bottom of the flume is shaped with sand overlaid by rip-rap in both upstream and downstream reaches. The glass panels allow visual observation and photographing of the flow patterns and other related phenomena in the vicinity of the tested structure.

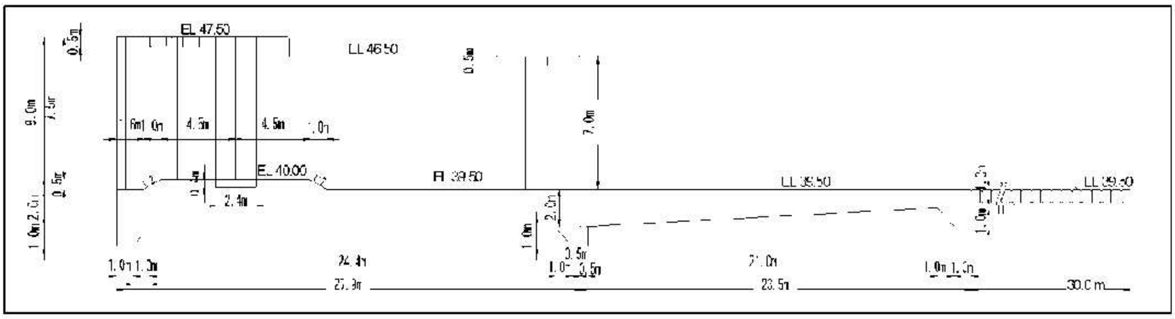


Figure 3-3.1 Layout plan in physical hydraulic model test

Source: Report Draft (2D Model)

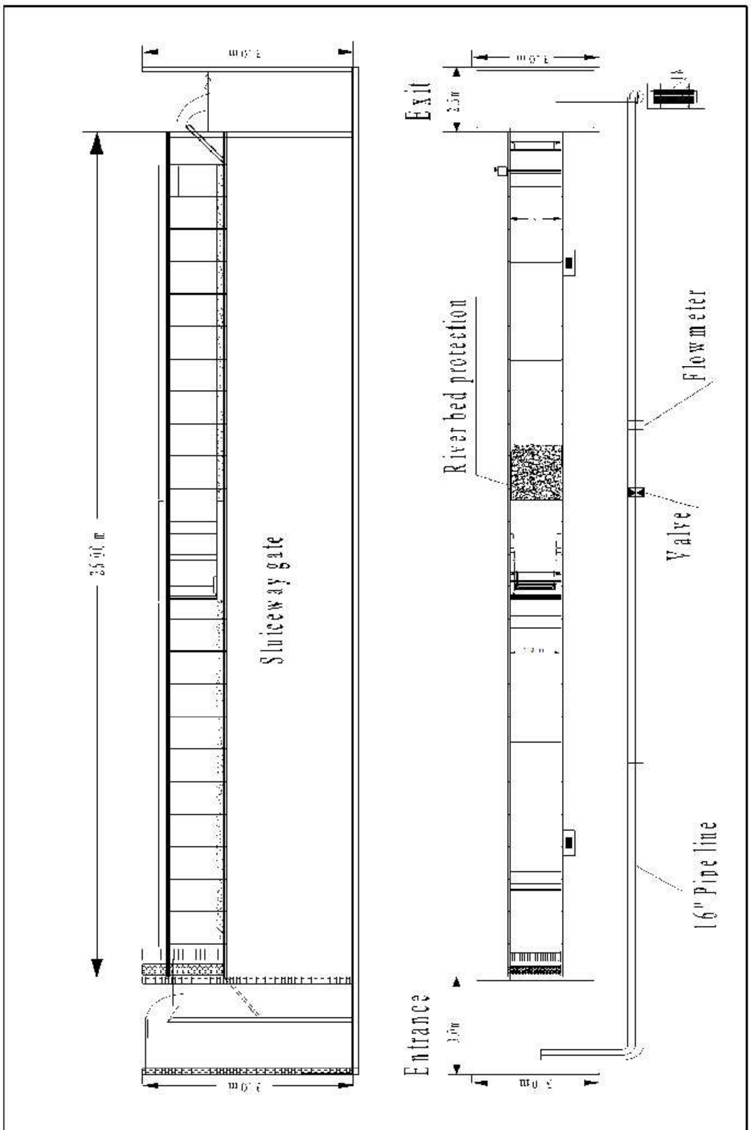


Figure (2-1) Model Layout in the Flume

Figure 3-3.2 Layout plan of flume in physical hydraulic model test

Source: Report Draft (2D Model)

c) Similarity rules

This physical hydraulic model test targets the flow of a canal with the free water surface, and the flow is mainly dominated by gravity and inertia. Therefore, Froude's similarity rules are applicable to the canal flow.

The scale of the physical hydraulic model test facility is 1/8.5 in all the directions. The similarity rules applicable to each hydraulic quantity item are shown below.

Table 3-3.1 Similarity rules

Hydraulic Quantity Item	Unit	Scale	Model Scale
Length/Depth	m	$n_L = n_{model} / n_{prototype}$	1/8.5
Area	m^2	$n_A = n_L^2$	1/72.25
Flow Velocity	m/s	$n_V = n_L^{1/2}$	1/2.92
Discharge	m^3/s	$n_Q = n_L^{5/2}$	1/210.64

(1) Test Measurement Items

The measurement items for the physical hydraulic model test will be described below.

a) Inflow

The inflow water from the upstream side of the physical hydraulic model test equipment is pumped up from the underground reservoir tank and supplied through the pipeline. Therefore, the inflow is measured by the ultrasonic flow meter installed on the water supply pipeline of 16-inch diameter.

Plate (5) Ultra-Sonic Flowmeter for Inflow Discharge to the Model

Figure 3-3.3 Inflow measuring equipment (ultrasonic flow meter)

Source: Report Draft (2D Model)

b) Water level

The water level is measured by the point gauge fixed at the upstream and downstream points at 60 m from the regulator crests of the scale used in the field.

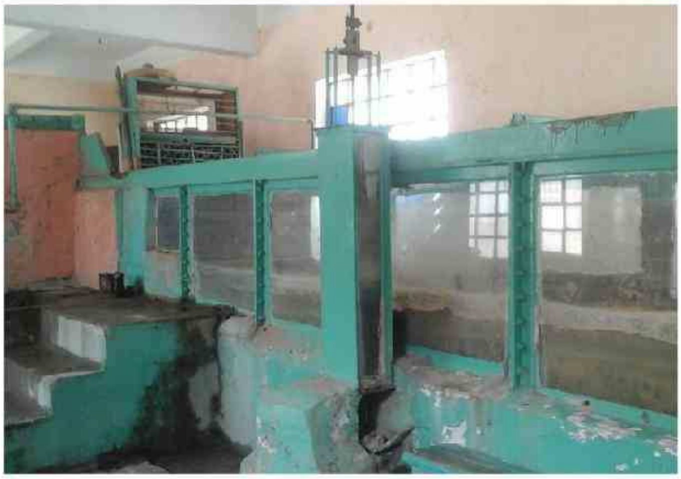


Figure 3-3.4 Water level measuring equipment (point gauge)

c) Flow velocity

The flow velocity can be measured on an arbitrary survey line and at an arbitrary depth by the use of a micro current meter. The average flow velocity for the measuring time duration is calculated and indicated on the meter.

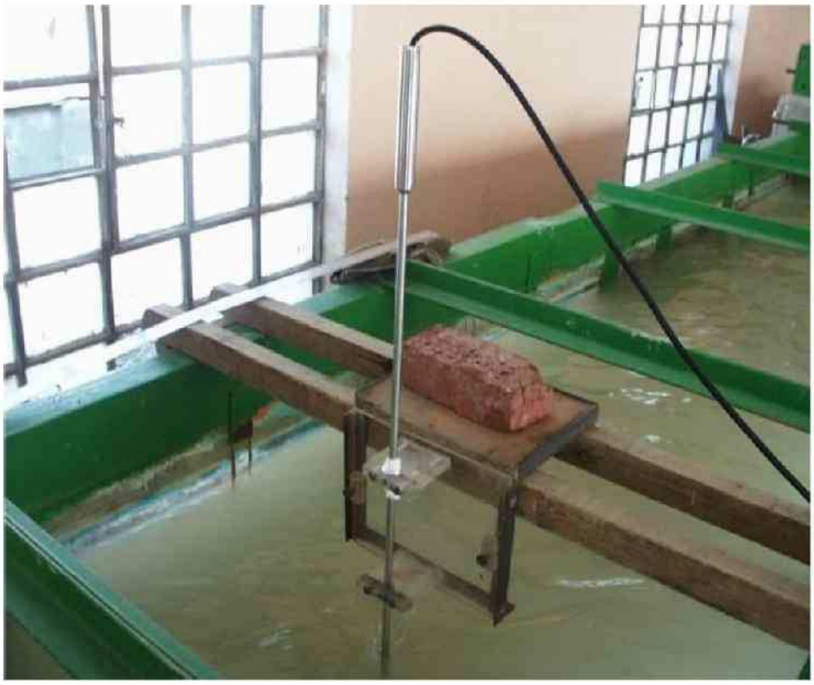


Figure 3-3.5 Flow velocity measuring equipment (micro current meter)

d) Water pressure

The water pressure is described in the "Report Draft (2D Model)" as follows:

> In order to measure the pressure distribution on the horizontal apron, eight (8) cells 37.93 m apart (prototype scale) were fixed at the centerline of the apron surface. These cells are connected to eight (8) glass water manometers fixed on a vertical board to directly determine the pressure head above the inclined and horizontal apron.

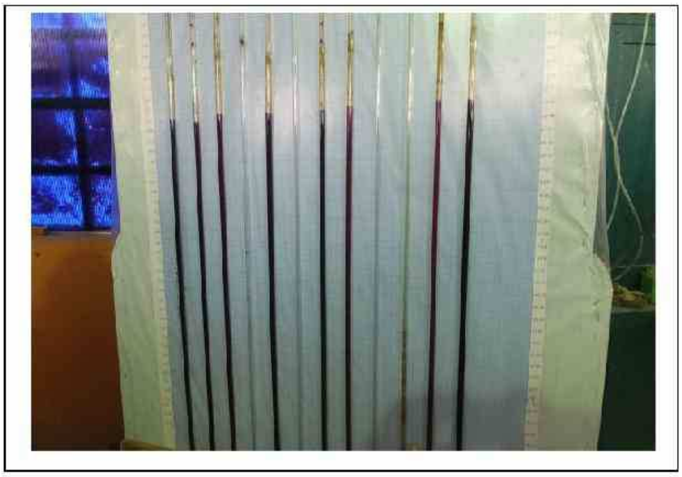


Figure 3-3.6 Water pressure measuring equipment (piezometer)

e) Test cases

The test of the detailed regulator models is conducted in three cases, each of which consists of a series of tests to attain its purpose.

Table 3-3.2 Test cases

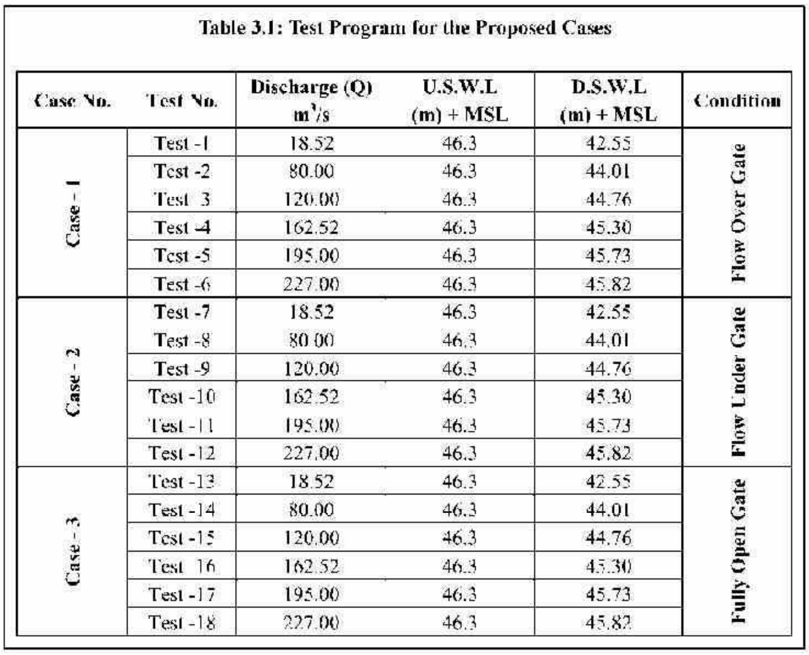


Table 3.1: Test Program for the Proposed Cases

Case No.	Test No.	Discharge (Q) m^3/s	U.S.W.L (m) + MSL	D.S.W.L (m) + MSL	Condition
Case - 1	Test -1	18.52	46.3	42.55	Flow Over Gate
	Test -2	80.00	46.3	44.01	
	Test -3	120.00	46.3	44.76	
	Test -4	162.52	46.3	45.30	
	Test -5	195.00	46.3	45.73	
	Test -6	227.00	46.3	45.82	
Case - 2	Test -7	18.52	46.3	42.55	Flow Under Gate
	Test -8	80.00	46.3	44.01	
	Test -9	120.00	46.3	44.76	
	Test -10	162.52	46.3	45.30	
	Test -11	195.00	46.3	45.73	
	Test -12	227.00	46.3	45.82	
Case - 3	Test -13	18.52	46.3	42.55	Fully Open Gate
	Test -14	80.00	46.3	44.01	
	Test -15	120.00	46.3	44.76	
	Test -16	162.52	46.3	45.30	
	Test -17	195.00	46.3	45.73	
	Test -18	227.00	46.3	45.82	

* Source: Draft Report (2D Model)

(2) Test monitoring and advice

a) Model manufacture

Details of the model manufacturing are described in the "Draft Report (2D Model)" as follows:

> The model structure is made from Plexiglas material in a steel-framed glass walled flume of 26.0 m long, 1.0 m wide, and 1.2 m height.
>
> The glass panels allow visual observation and photographing of the results of the flow patterns and other related phenomena in the vicinity of the tested structure. The model was constructed inside the Northern flume of HRI.
>
> The modeled structure consists of one bay of the sluice way consists of two half piers of 1.25 m wide each (prototype scale) manufactured from Plexiglas. The upstream water level controlled by two gates made of Plexiglas each gate with 3.3m height. In the first test case the gates used as a weir.
>
> Under normal operations (case-2), the flow passes between the gate and the sill under gate which was made of wood in the model. The Stilling basin consists of 2 parts; Sill under gate followed by a horizontal apron. Both of them are made from special water tight wood.

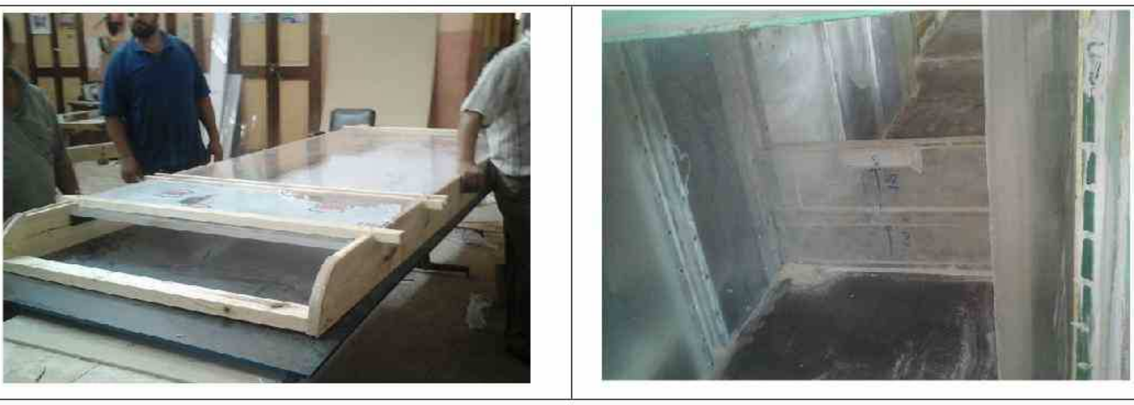


Figure 3-3.7 Gate manufacture

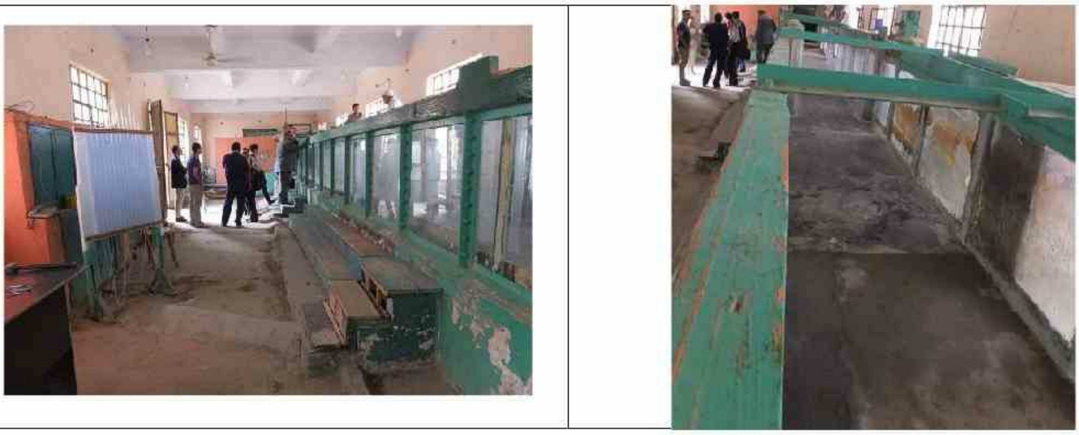


Figure 3-3.8 2D Model manufacture

Figure 3-3.9 Installation of regulator piers

b) Test measurements

In the 2D physical hydraulic model test, the water level is measured by a point gauge and the flow velocity by a micro current meter.

The flow velocity at each depth is measured in each of 6 cross sections in the center of the canal. The flow velocity distribution at the time of maximum discharge due to overflow is shown below.

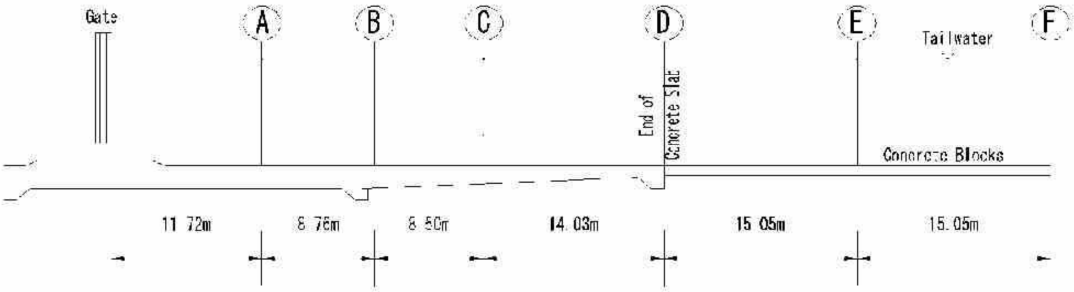


Figure 3.3 Locations of the Cross Section Velocity Measurements

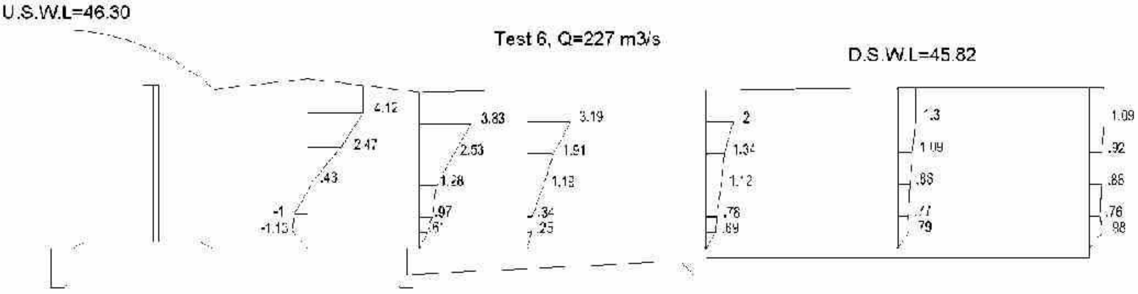


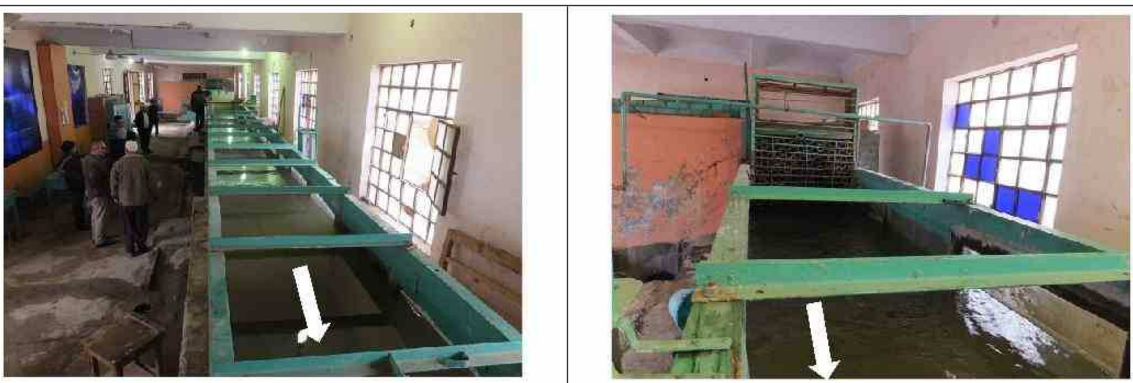
Figure 4.6 Velocity Distribution, Test-6, Case-1, Flow over Gate

Figure 3-3.10 Measuring positions and results of cross-sectional flow velocity measurements

Source: Draft Report (2D Model)

c) Analysis of phenomena

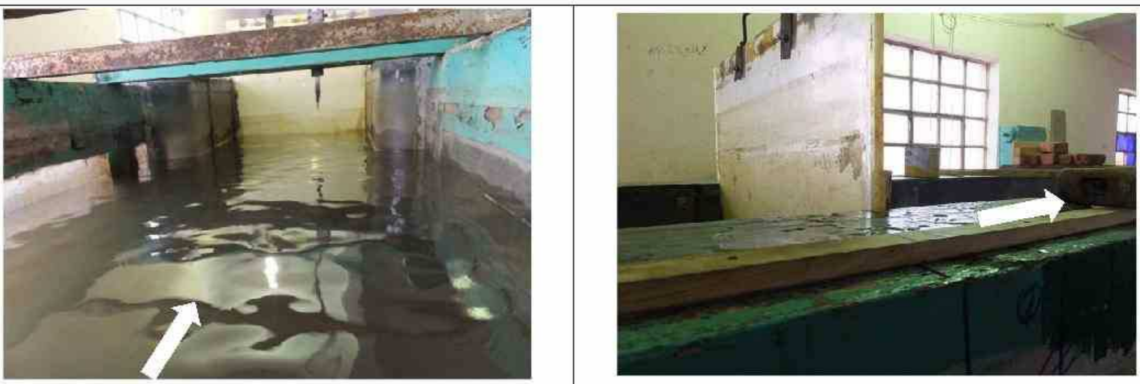
It was confirmed that the upstream flows of the new regulator in the 2D physical hydraulic model test facility were gentle and smooth. However, it was noticed that some turbulence was generated in the downstream flow of the new regulator.



Downstream flow

Upstream flow

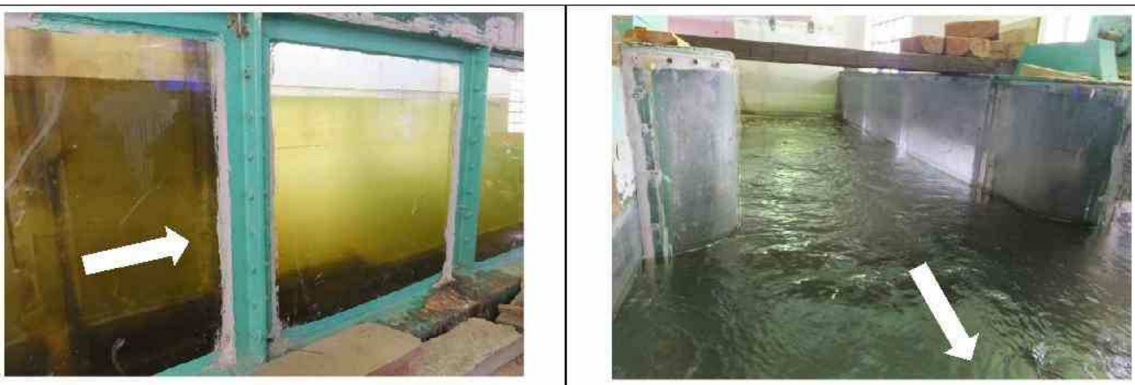
Figure 3-3.11 Flow conditions in 2D model (1)



Upstream flow

Downstream flow of a gate

Figure 3-3.12 Flow conditions in 2D model (2)



Side view of downstream flow

Downstream flow near the regulator’s piers

Figure 3-3.13 Flow conditions in 2D model (3)

3-4 Integrated evaluation of physical hydraulic model tests

(1) Basic Policy of Integrated Evaluation

The integrated evaluation of the physical hydraulic model tests of the NDGRs was carried out by the HRI in accordance with the recommendation of two types of physical hydraulic model test as described in the report.

The report drafts on the two physical hydraulic model tests are as follows:

1) 3D Model (Received on November 29, 2016)

Report Draft on the Hydraulic Model Test of the DGRs, Installation of the New Regulators and Flow Velocity Measurement (November 2016)

Comments to RGBS submitted on: December 27, 2016)

Response from RGBS received on: February 2, 2017)

2) 2D Model (Received on February 9, 2017)

Final Report* on the 2 Dimensional Model for Bahr Yusef New Regulator (January 2017)

* The title of this report is “Final Report”, but it is the Final Report Draft.

(2) Conclusion and Recommendations on Hydraulic Model Tests

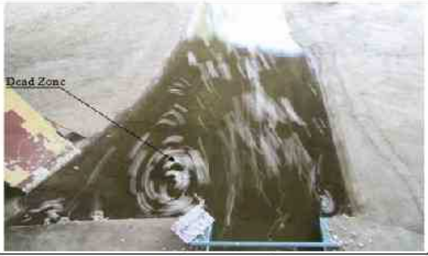
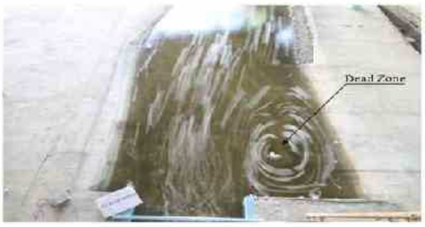
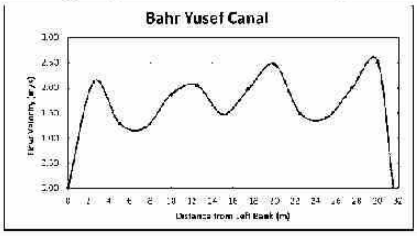
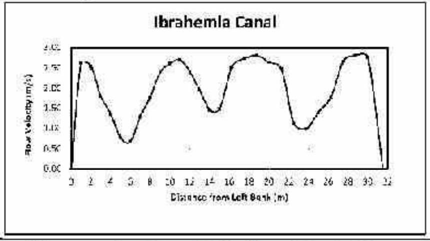
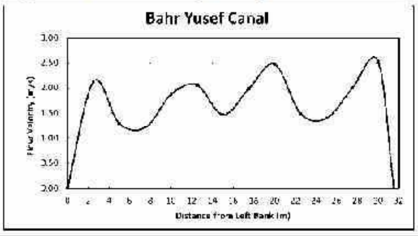
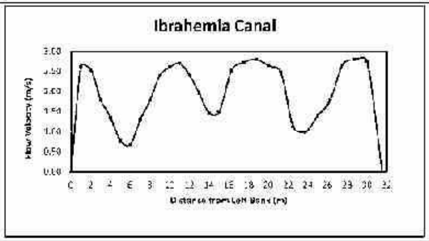
a) 3D hydraulic model test

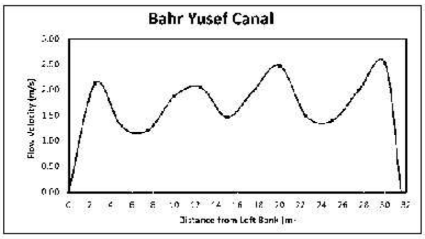
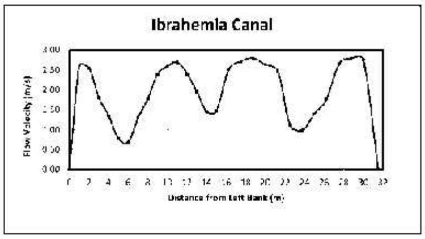
Regarding the Draft Final Report on the Hydraulic Model Tests that were carried out by HRI, the D/D consultant accepted the response by RGBS as of February 2, 2017 to HRI’s comments, because the flow distribution and flow velocity tendency were the same as the results of hydraulic analyses though the hydraulic conditions of the models were slightly different.

The D/D consultant submitted its comments to RGBS regarding portions of the Report Draft that could not be understood. Upon receiving the response from RGBS, the Study team verified its contents and everything that it could not understand was made clear. Thus, the D/D consultant has no objection to the response by RGBS.

The conclusions as described in the Final Report Draft on 3D Model are as described below. The study team accepted those conclusions including the response to the comments and reflected those on the design.

Table 3-4.1 Conclusion of 3D Model draft final report and its evaluation

<table>
<tr><th>Item</th><th colspan="2">Conclusion</th><th>Evaluation</th></tr>
<tr><td rowspan="3">Dead zones</td><td colspan="2">• Formation of dead zones downstream of the new regulators at Bahr Yusef and Ibrahimia Canal.</td><td rowspan="3">Accepted</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Bahr Yusef</td><td>Ibrahimia</td></tr>
<tr><td rowspan="3">Influence on the new regulator</td><td colspan="2">• The flow distribution amongst the gates of the new regulators is influenced by the upstream arrangements such as the lock situation and the arrangement of the existing regulator vents with respect to the new regulator vents.</td><td rowspan="3">Accepted</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Flow velocity at DS Bahr Yusef Reg.</td><td>Flow velocity at DS Ibrahimia Reg.</td></tr>
<tr><td rowspan="3">Water level</td><td colspan="2">• The water level in Ibrahimia Canal upstream of the existing regulator (DGRs) is influenced by the pool formed at water level of 46.30 m (MSL) between the existing and the new regulators.</td><td rowspan="3">Accepted by reply (The water level of 46.30 m is the level upstream the existing regulator.)</td></tr>
<tr><td colspan="2">(Comment to HRI through RGBS)
(4) It is serious contradiction that "water level of 46.30 m (MSL) between the existing and the new regulators" although the design water level, EL.46.30m, is at the upstream of the existing regulators.</td></tr>
<tr><td colspan="2">(Reply from HRI through RGBS)
The upstream water level used in the model is 46.30 m and this is the level upstream the existing regulator. This statement will be modified in the updated report.</td></tr>
<tr><td rowspan="3">Influence of the piers</td><td colspan="2">• The flow distribution shape downstream the new regulator, especially at section (1), is influenced by the piers of the regulator.</td><td rowspan="3">Accepted</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Flow velocity at DS Bahr Yusef Reg.</td><td>Flow velocity at DS Ibrahimia Reg.</td></tr>
<tr><td>Maximum flow</td><td colspan="2">• The maximum flow velocity at downstream the new regulator of Ibrahimia Canal is 2.8 m/s, while it is 2.52 m/s for Bahr Yusef Canal.</td><td>Accepted by reply.</td></tr>
</table>

<table>
<tr><th>Item</th><th colspan="2">Conclusion</th><th>Evaluation</th></tr>
<tr><td rowspan="4">velocity</td><td>
Figure (4): Bottom Flow Velocity Distribution at Cross Section 1</td><td>
Figure (2): Bottom Flow Velocity Distribution at Cross Section 1</td><td rowspan="4">Hydraulic conditions of model are slightly different at Bahr Yusef.</td></tr>
<tr><td>Flow velocity at DS Bahr Yusef Reg.</td><td>Flow velocity at DS Ibrahimia Reg.</td></tr>
<tr><td colspan="2">(Comment to HRI through RGBS)
(5) The description “It is not recommended to measure the flow velocity distribution in this vicinity because it gives ambiguous results” has an inconsistency with the description “The maximum flow velocity at downstream the new regulators of Ibrahimia Canal is 2.8m/s, while it is 2.52m/s for Bahr Yusef Canal.”</td></tr>
<tr><td colspan="2">(Reply from HRI through RGBS)
The statement will be changed in the updated report to be " measuring the flow velocity in the downstream of the new regulator should consider the turbulence that occur in this vicinity"</td></tr>
<tr><td>Remove the dead zones</td><td colspan="2">• It is recommended to remove the dead zones downstream the new regulators of Bahr Yusef and Ibrahimia Canals. This can be one by filling these zones with a filler material (e.g. sand, silt and clay mixture) and consider it as part of the bank of the canal.</td><td>Accepted
It reflected in the design.</td></tr>
<tr><td>Cross section (1)</td><td colspan="2">• Cross section (1) is located in highly turbulent and hydraulically unstable vicinity.</td><td>Accepted</td></tr>
<tr><td>Flow velocity at cross section (1)</td><td colspan="2">• It is not recommended to measure the flow velocity distribution in this vicinity because it gives ambiguous results.</td><td>Accepted</td></tr>
</table>

b) 2D hydraulic model test

The recommendations as described in the Final Report on “2D Model” are shown in the table below.

The D/D consultant accepted those recommendations and agreed to reflect them on the design.

Table 3-4.2 Recommendations and evaluations on 2D Model

Item	Recommendation	Evaluation
The type of bed protection	• No need for the area with concrete blocks downstream the apron and it can be replaced by riprap protection.	Accepted
The length of the riprap protection	• The length of the riprap protection D/S the apron can be taken as 20-30 m.	Accepted

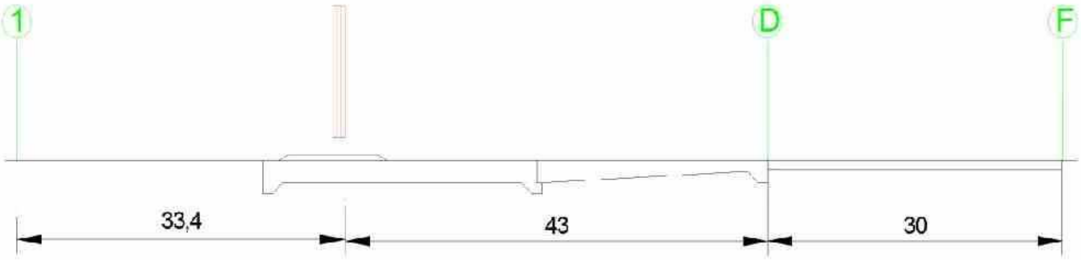


Figure 4.23 Location of Calculation of Stability of River Bed Protection

Table 4.10 shows the stability coefficient B' as calculated from modified formula with the measured standard deviation of the velocity fluctuations at the two cross sections **(D)** and **(F)** for tests from 1 to 12. Based on the measured near bed velocity fluctuation and the standard deviation the stability coefficient B' was found safe for all tested flow conditions of the Cases of flow over gate and flow under gate, see **Figures 4.24and 4.25**.

Table (4.10) Stability Coefficient for Rip-Rap Protection at Cross Sections D and F

(Case-1 and Case-2)

Test No.	Q m^3/s	Cross Section (D)				Cross Section (F)			
		$V_{0.9}$ (m/s)	SD.V	B'	Safety	$V_{0.9}$ (m/s)	SD.V	B'	Safety
Test - 1	**18.52**	0.109	0.018	0.063	Safe	0.180	0.021	0.105	Safe
Test - 2	**80**	0.372	0.135	0.288	Safe	0.338	0.062	0.221	Safe
Test - 3	**120**	0.545	0.269	0.542	Safe	0.496	0.101	0.355	Safe
Test - 4	**162.52**	0.429	0.328	0.468	Safe	0.766	0.161	0.625	Safe
Test - 5	**195**	0.846	0.300	0.885	Safe	0.868	0.107	0.631	Safe
Test - 6	**227**	0.685	0.516	0.961	Safe	0.979	0.135	0.757	Safe
Test - 7	**18.52**	0.075	0.024	0.044	Safe	0.153	0.034	0.093	Safe
Test - 8	**80**	0.385	0.106	0.279	Safe	0.397	0.070	0.265	Safe
Test - 9	**120**	0.542	0.224	0.499	Safe	0.526	0.057	0.339	Safe
Test - 10	**162.52**	0.818	0.331	0.898	Safe	0.535	0.082	0.366	Safe
Test - 11	**195**	0.584	0.298	0.609	Safe	0.613	0.110	0.449	Safe
Test - 12	**227**	0.937	0.398	1.132	Safe	0.947	0.100	0.677	Safe

Source: 2D Model (p40), Test 1-6: Overflow, Test 7-12: Underflow

＜Considerations＞

The D/D consultant confirmed the following points on the gate operation based on the results described in the Report, which will be specially described as follows:

The result of overflow gate operation at the time of maximum discharge (Test-6) indicates that the water level of the upstream of the regulators exceeds the target upstream water level of EL. 46.30 m.

This result suggests that the maximum discharge is not allowed by the overflow gate operation. Therefore, the maximum discharge should be made by the underflow gate operation on the condition that the gate opening is 2.5 m or more.

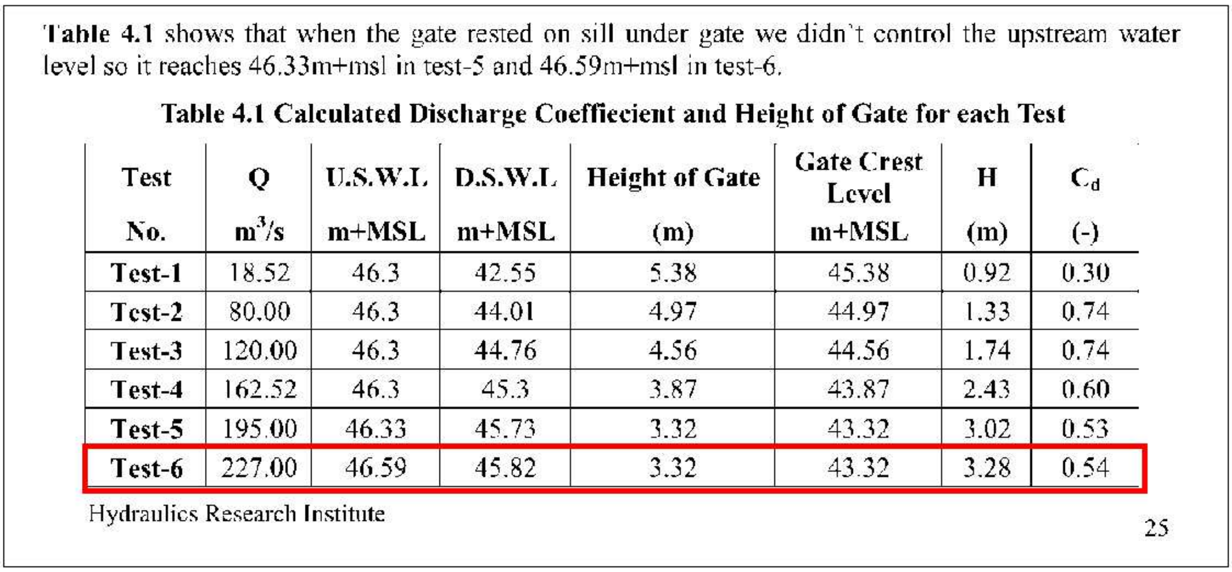


Table 4.1 shows that when the gate rested on sill under gate we didn't control the upstream water level so it reaches 46.33m+msl in test-5 and 46.59m+msl in test-6.

Table 4.1 Calculated Discharge Coeffiecient and Height of Gate for each Test

Test No.	Q m^3/s	U.S.W.L m+MSL	D.S.W.L m+MSL	Height of Gate (m)	Gate Crest Level m+MSL	H (m)	C_d (-)
Test-1	18.52	46.3	42.55	5.38	45.38	0.92	0.30
Test-2	80.00	46.3	44.01	4.97	44.97	1.33	0.74
Test-3	120.00	46.3	44.76	4.56	44.56	1.74	0.74
Test-4	162.52	46.3	45.3	3.87	43.87	2.43	0.60
Test-5	195.00	46.33	45.73	3.32	43.32	3.02	0.53
Test-6	227.00	46.59	45.82	3.32	43.32	3.28	0.54

Hydraulics Research Institute

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Source: 2D Model (p. 25), Test 1-6: Overflow

(3) Integrated Evaluation of Hydraulic Model Tests

As a result of having examined the application of the recommendations on the two hydraulic model tests to the design, the consultant decided to reflect those recommendations on the design and wrapped up into the final design.

However, RGBS and HRI are planning to conduct the second stage of hydraulic model test aimed at the final confirmation on the design plan on which the form of revetment work and the scale of bed protection work are reflected based on the results of the 2 hydraulic model tests.

These results will be wrapped up after completion of this Study, and the length of bed protection may be changed in future.

a) Reflection of 3D hydraulic model test on the design

In the Draft Final Report on 3D Model, it is recommended to remove and fill the dead water regions on the downstream side of the new regulators in the Bahr Yusef canal and the Ibrahimia canal.

As the result of examination of this recommendation by the design group, the dead water regions on the downstream side of the new regulators were removed and their forms were corrected.

The change of the form in the latest design is shown below.

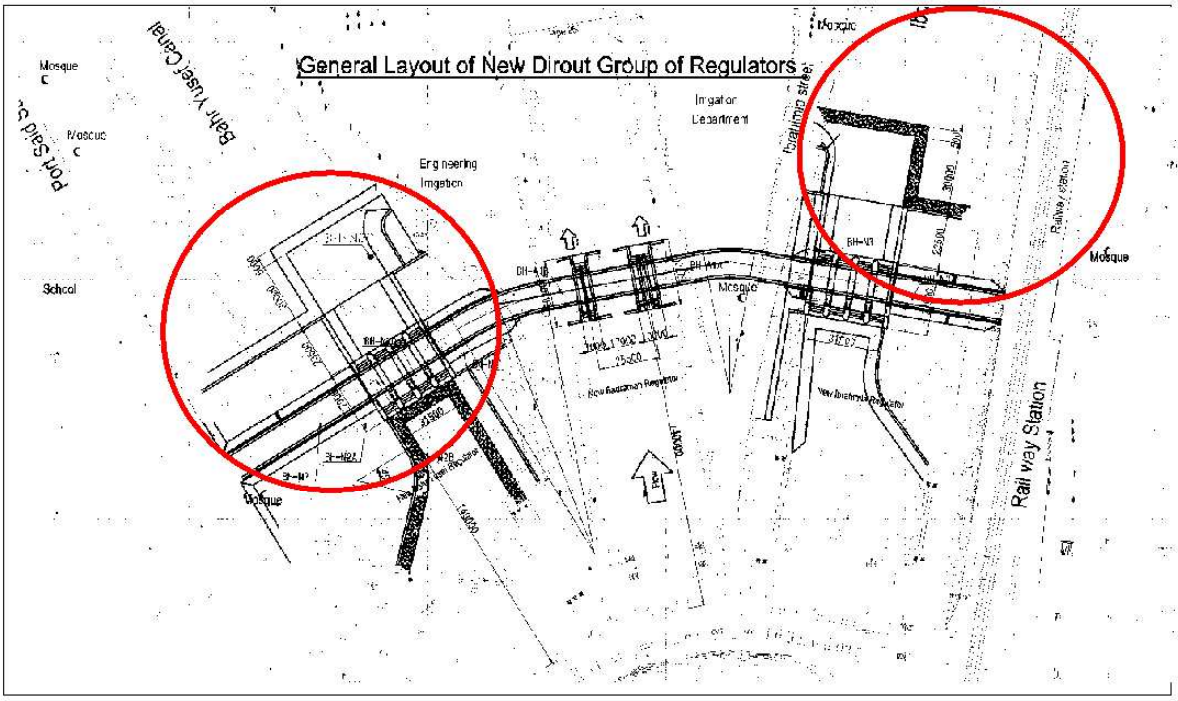
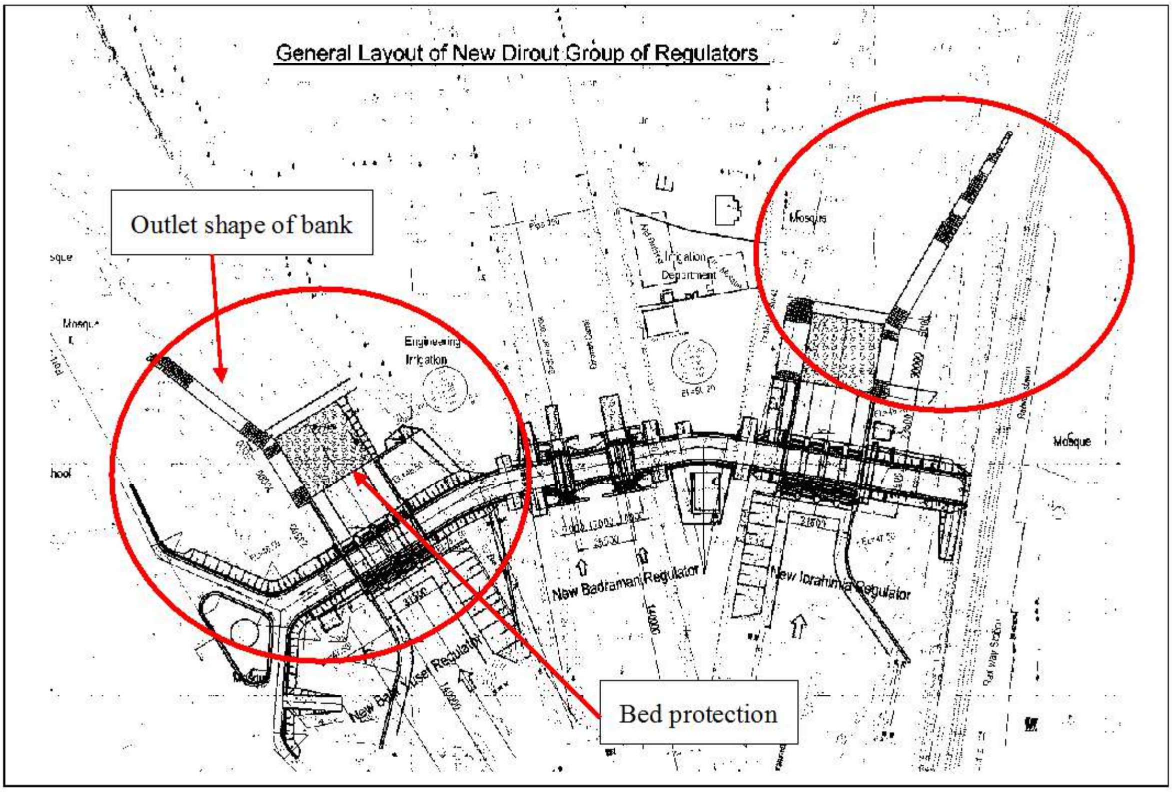


Figure 3-4.1 General layout of NDGRs (initial layout)



Outlet shape of bank

Bed protection

Figure 3-4.2 General layout of NDGRs (changed)

b) Reflection of 2D hydraulic model test on design

As described above, the range of streambed protection (20 to 30 m) and its type, which were determined in accordance with the Design Standard in Japan, are recommended in the Final Report Draft on 2D Model.

Based on the above recommendation, the design appropriateness of the range of streambed protection and its type has been confirmed as follows:

1) Length of bed protection work

Large-scale regulators (Bahr Yusef and Ibrahimia): 30 m

Small-scale regulators (Badraman and Diroutiah): 15 m

2) Type of bed protection work

Riprap

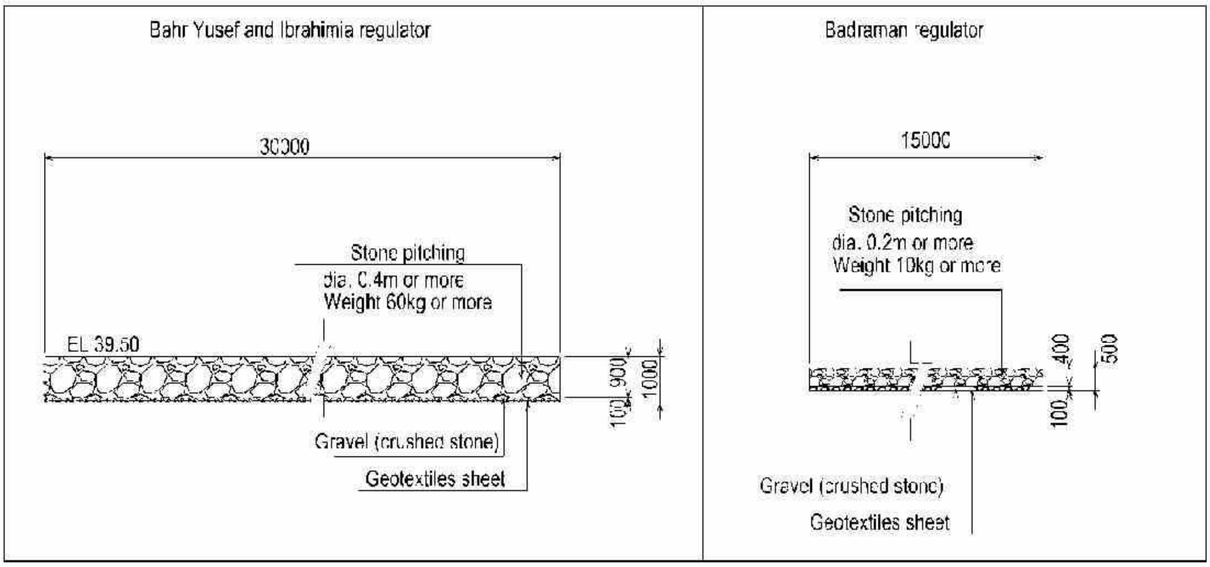


Figure 3-4.3 Sectional diagrams of bed protection works

Volume VII　RECOMMENDATIONS

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2. Water Management System ································· VII- 2
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5. Bidding Process and Construction Contract ··············· VII- 3
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7. Mathematical Model Analysis ······························ VII- 4

Volume VII RECOMMENDATIONS

Based on the result of the detailed design study, the following recommendations are provided.

1. Regulator Design

(1) The design water level at downstream of each regulators as the basic design conditions of the NDGRs are provided from the conditions of the canal sections rehabilitated completely. The implementation of the canal rehabilitation should be done immediately to realize the proper water distribution in accordance with design discharge from the each regulator.

(2) The H-Q curve at each canal should be prepared to realize the accurate water distribution from NDGRs. The periodical observation of the discharge at the location defined should be done.

(3) The plate bearing test at the site should be done for the ultimatum confirmation of the bearing capacity of the foundation after the completion of the excavation till the design foundation level on each regulators.

(4) The building works is necessary to conduct at least two borings in the control house and stoplogs house in order to confirm the bearing capacity

(5) The road alignment on the railway crossing to the national railway at right bank of Ibrahimia canal will be planned and designed by the national consultant who contracts with the Assiut Governorate. The implementation agency should confirm the ultimatum plan and design so as not to affect the NDGRs project.

(6) The construction works on the Abo Gabal and Sahelyia regulators located at upstream are necessary to partly demolish the existing ones and connect between the new and the existing ones as the one body structures. The discussion and organization with the Ministry of Antiquities and the other agency related should be done immediately.

(7) The sedimentation concerned in the vicinity of the NDGRs is necessary to remove for the proper operation of the NDGRs. The periodical dredging works as the maintenance works should be maintained as well as the existing works.

(8) The ground water level will be raised, which effect will be small and limited, after the construction works of NDGRs in the ground water analysis. Based on the result of the analysis, the monitoring and the analysis of the ground water should be maintained and studied.

2. Water Management System

(1) Water level sensors at the branch canal's intake will be installed two (2) years later after the commencement of the construction works of the NDGRs. Therefore, at the current situation of the D/D stage, the detailed location for water level sensor's installation has not been confirmed yet. It is recommended to finalize the installation location of the water level sensor by the executing agency and the S/V Consultant after the commencement of construction works.

(2) In order to realize the adequate water management from the main canal to branch canal, it is necessary to open and close the branch canal's gate appropriately. At the present situation, some of the intake gates along the branch canal could not open and close due to their deterioration, breakage of actuators for gates and etc. It is, therefore, recommended that the executing agency discusses the restoration works of intake gate with ID.

(3) In this project, it is planned that the operating status data of pump stations owned and managed by MED will be grasped and transferred to the telemetry system. In order for the remote monitoring of pump status, it is necessary to modify the control panel of pump stations. Therefore, it is desirable to clarify the demarcation of the expense and responsibility with MED for modifying the electrical devices from the early stage before the commencement of construction works. In this regard, it is recommended that the executing agency starts the discussion on modification works to monitor the operating condition of the pump status.

3. Construction Plan

(1) It was confirmed through the discussions with RGBS that the temporary yard for concrete batching plant and aggregate bin shall be secured at the site of the existing irrigation department office between Ibrahimia and Badraman canal. The building shall be relocated before commencement of the Project. On the other hand, the sites for other temporary facilities and stock yards which needs two years after the implementation of the construction will be selected among the adjacent candidate sites after D/D study. It is, therefore, recommended that the executing agency starts negotiation on lease agreement with land owners as soon as possible.

(2) It is recommended to discuss with the authorities of rail way about the position and method with considering the vibration for the sheet piles that is driven parallel with the railway on the right bank of Ibrahimia canal to protect the slope from collapse.

4. Project Cost Estimation

(1) The detailed project cost of the NDGRs was estimated assuming that the project will be commenced in February 2018. Since the commencement date of the project is an

important factor affecting the project cost, it is recommended to decide the commencement date as soon as possible to secure the accurate project cost.

(2) In the detailed design period, it was unstable in the Egyptian market because a fixed exchange rate system was shifted to a flexible exchange rate system. Because the project cost estimation had to be carried out such a period, an appropriate price escalation was required to be included in the project cost estimation as the price contingency. In order to set up a bidding price in high accuracy, it is recommended to review the exchange rate and price escalation rate.

5. Bidding Process and Construction Contract

(1) It is important that the procurement process for the construction contract shall be executed as originally planned, i.e. commencement of construction contract shall be made by February 2018. Since the procurement process shall be made in accordance with JICA Guideline as agreed on the Minutes of Discussions on the Loan Agreement for the NDGRs, and also the bidding documents shall be subject to JICA's concurrence before distribution, it is recommended to use the draft Bidding Documents attached to this report without major alteration on the process and contents.

(2) It is recommended that technical specifications will be finalized based on its draft version prepared by the D/D consultant, taking into consideration the results of review on the detailed design and construction plan of the NDGRs will be done by S/V consultant.

6. Environmental and Social Consideration

(1) Given that the letter informing of approval of the EIA Report as of 9th September 2010, which was issued by EEAA, recommends implementation of groundwater level monitoring and groundwater quality check, and it is necessary to monitor those environmental items before and during construction stage.

(2) Piezometers for groundwater level monitoring are mostly located on the center of Dirout city, and they can be easily degraded. It is, therefore, recommended to maintain them monthly from just after the completion of the D/D to commencement of construction works.

(3) Groundwater level seems to be influenced widely by the canal water level, and it is recommended to pay attention to the change in the groundwater head at BH-N10, N11 and N12 where the hydraulic connection may exist between the canal water and the aquifer; moreover, at BH-N13 which has shallow groundwater level.

(4) Due to the construction of the NDGRs, the existing three (3) mosques are to be relocated to other sites. The new relocation sites of two (2) mosques, which are under the Ministry of Awqaf, have been already fixed, and they will be transferred before the construction

works. On the other hand, the last one which is under the control of the MWRI, will be relocated to the area owned by MWRI during the construction works. It is recommended to implement the relocation plan most certainly.

(5) There is the Lawyer's Club Café in the river bed which is operated illegally at just upstream of Abo Gabal Regulator. It is strongly recommended to take countermeasures against further expansion of the café to the construction site.

7. Mathematical Model Analysis

(1) Considering the smooth operation of the NDGRs in future, the sediments which are dredged every year around the existing DGRs should be examined from the view of river bed variation analysis. Based on the detailed bathymetric survey around the DGRs, it is significant for the reduction of the operation cost in future by predicting the future river bed variation and taking measures for less sedimentation. Therefore, it is recommended that;

1) to collect continuous measurement data of the sedimentation

2) to analyze the sedimentation tendency with the detailed river bed variation analysis, and

3) to take the countermeasures for less sedimentation.

ATTACHMENT

Drawings of NDGRs

AT-1. Civil Works Design of NDGRs-- AT-1

AT-2. Architecture Design of NDGRs -- AT-21

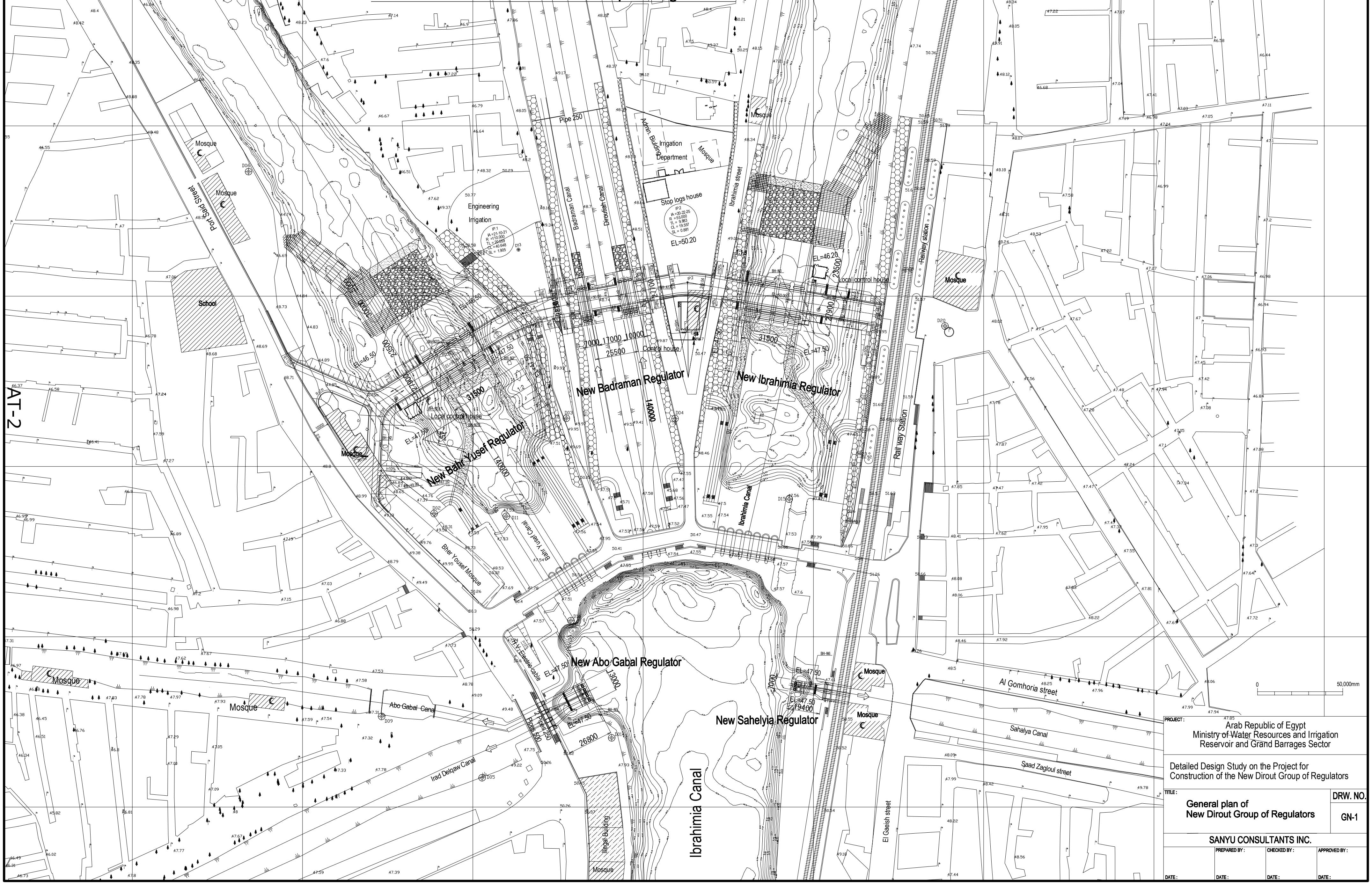
AT-3. Mechanical and Electric Works for Gate--- AT-26

AT-4. Temporary Works -- AT-33

AT-5. Water Management System --- AT-36

AT-1. Civil Works Design of NDGRs

General Plan of New Dirout Group of Regulators



PROJECT :

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

TITLE :

General plan of
New Dirout Group of Regulators

DRW. NO.
GN-1

SANYU CONSULTANTS INC.

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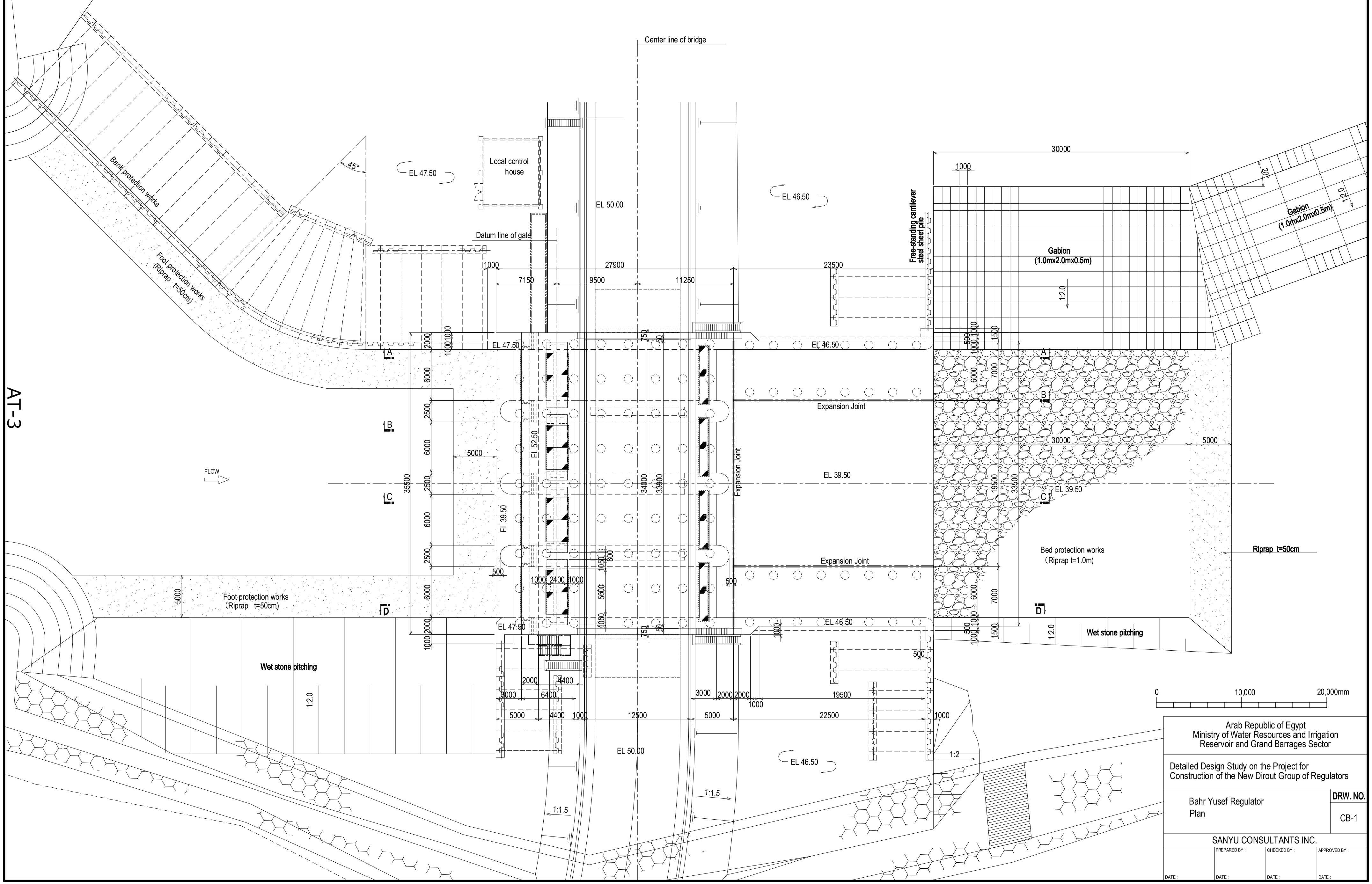
DATE :	DATE :	DATE :

DATE :

Plan of Bahr Yusef Regulator



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Detailed Design Study on the Project for
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Bahr Yusef Regulator
Plan

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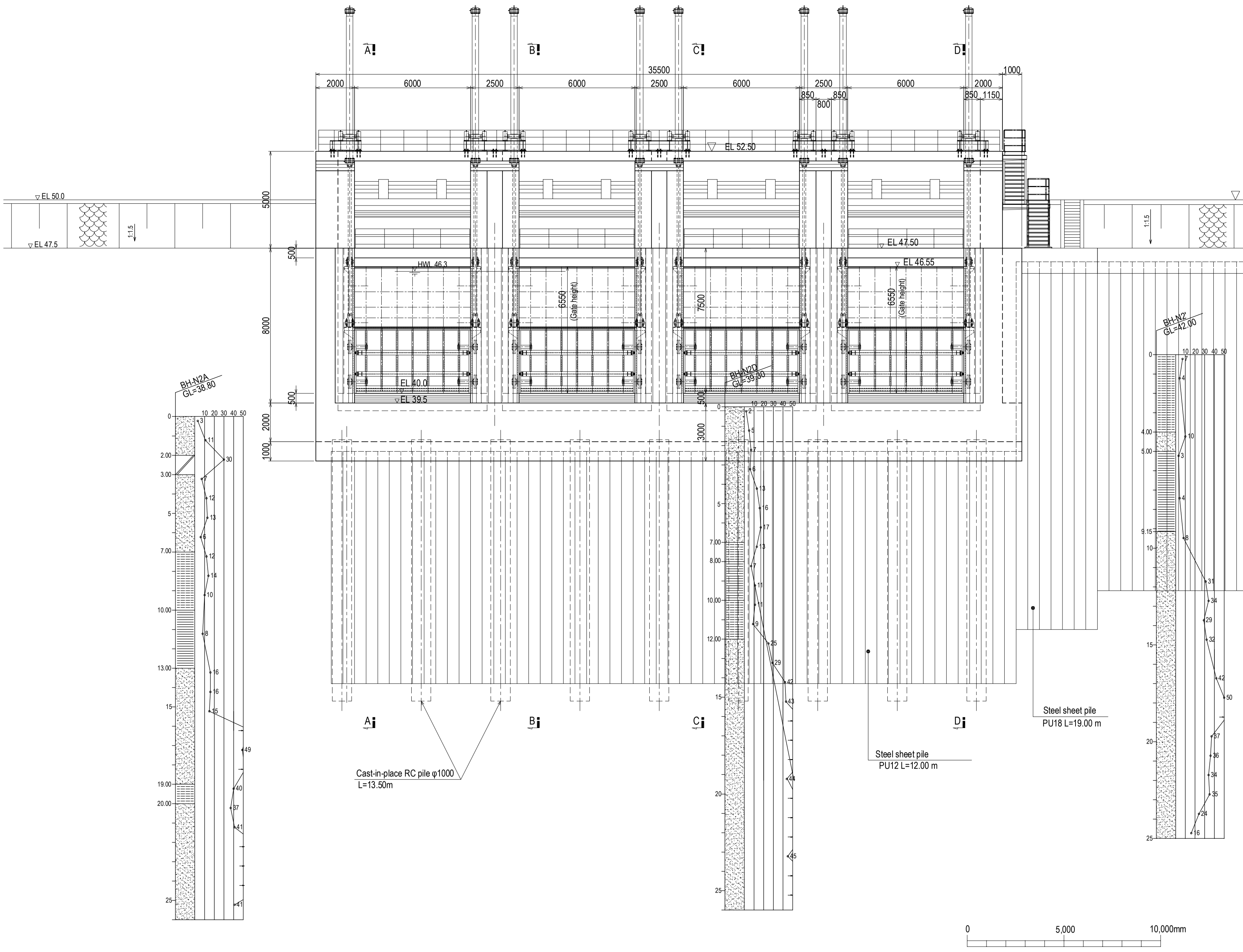
Elevation of Bahr Yusef Regulator



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Detailed Design Study on the Project for
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Bahr Yusef Regulator
Elevation

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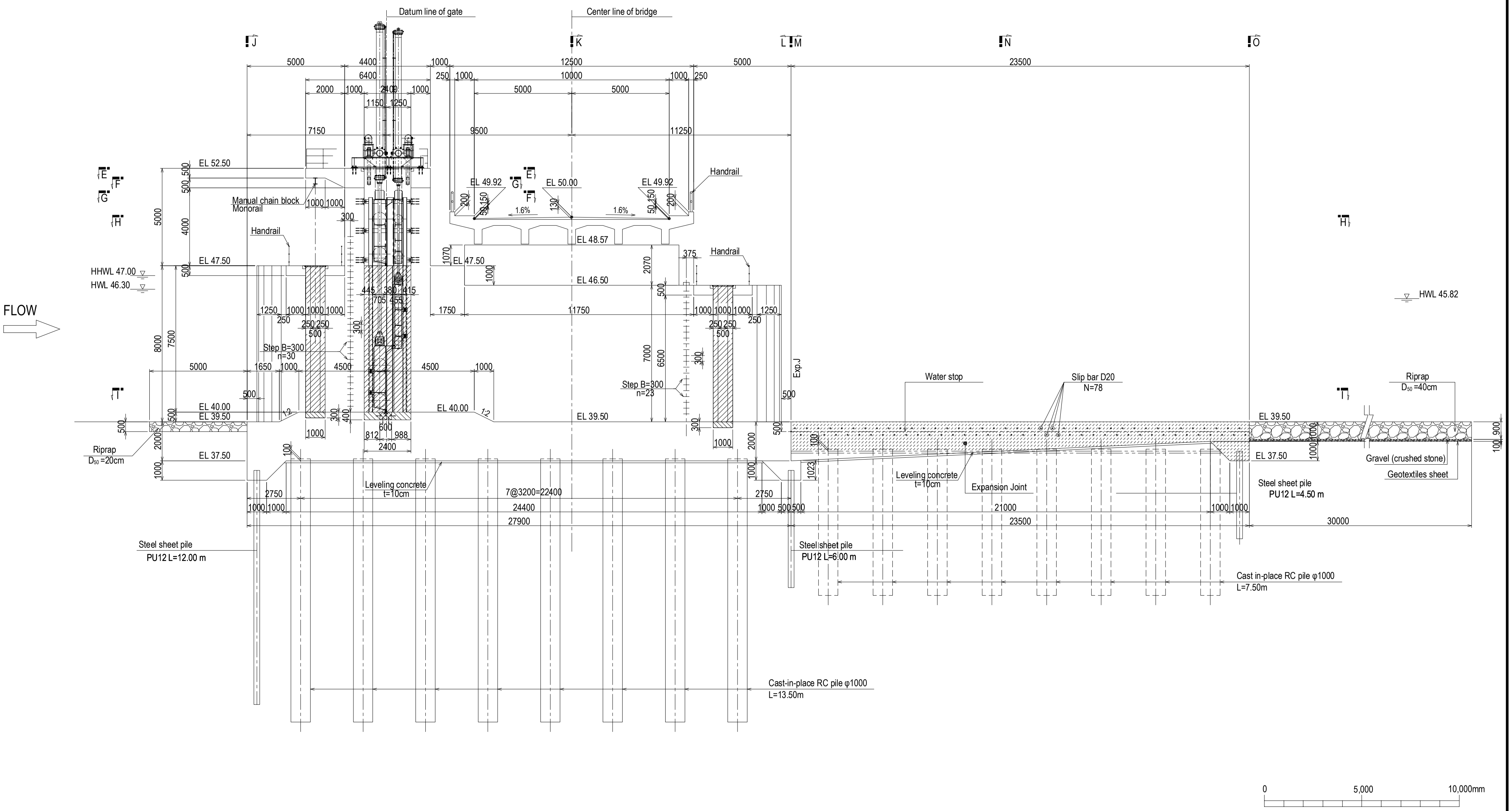
Longitudinal Section of Bahr Yusef Regulator（Section B－B）



Note;

▨ Shaded area indicates the range of second stage concrete to be placed with steel gate guide.

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Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
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Bahr Yusef Regulator
Longitudinal section (2)

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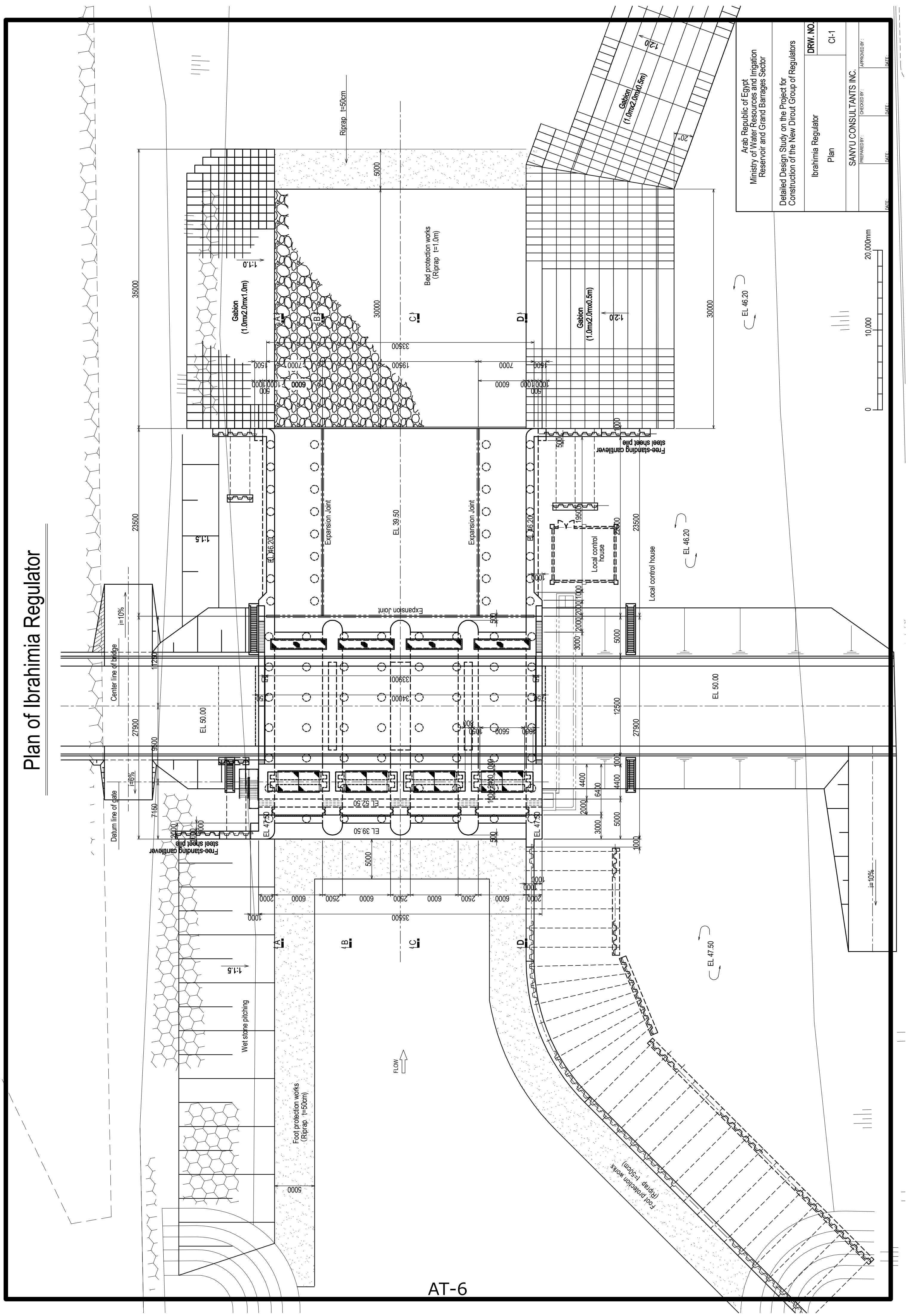
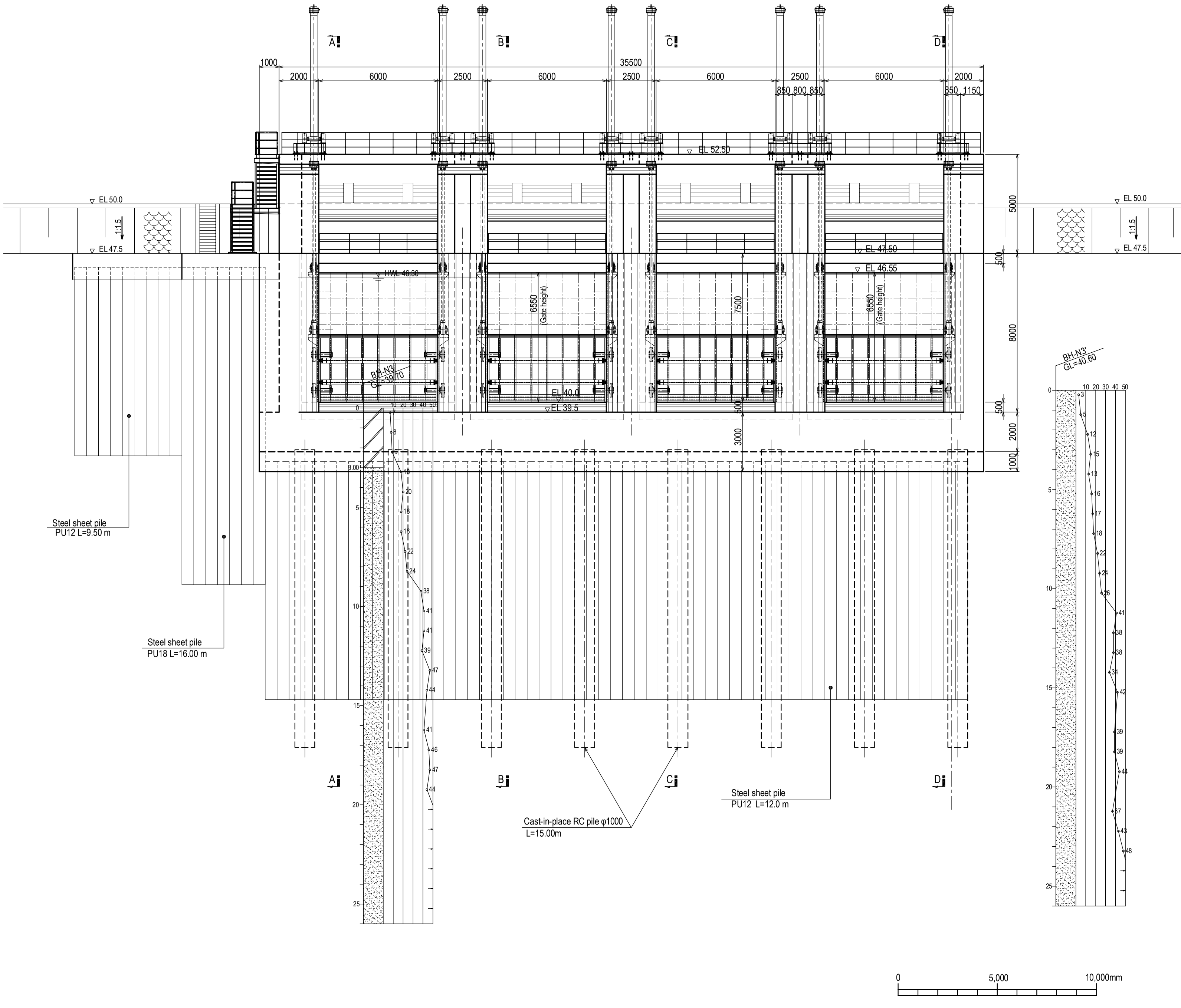
Plan of Ibrahimia Regulator



Elevation of Ibrahimia Regulator



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Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
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Ibrahimia Regulator
Elevation

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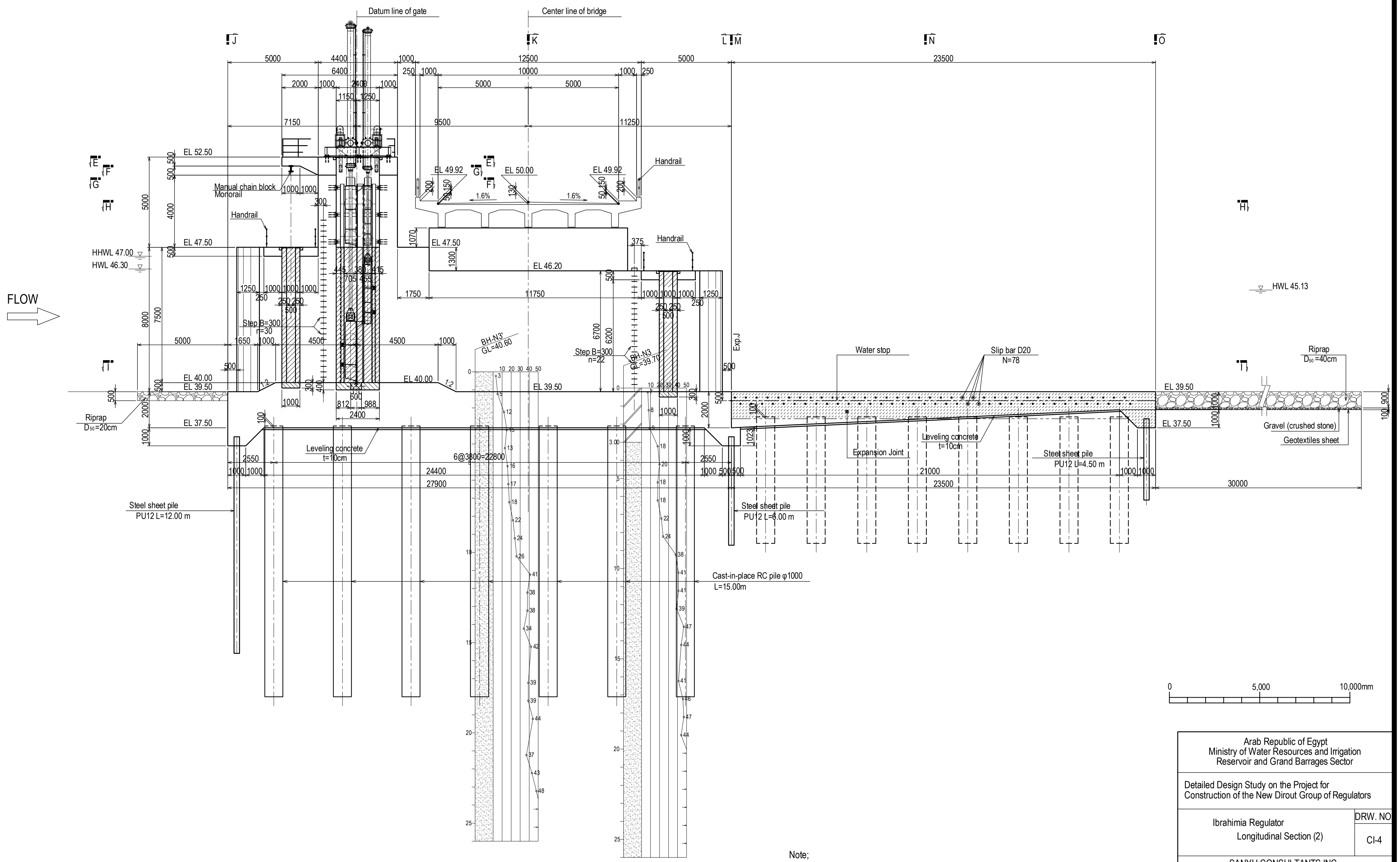
Longitudinal Section of Ibrahimia Regulator（Section B－B）



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Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Ibrahimia Regulator
Longitudinal Section (2)

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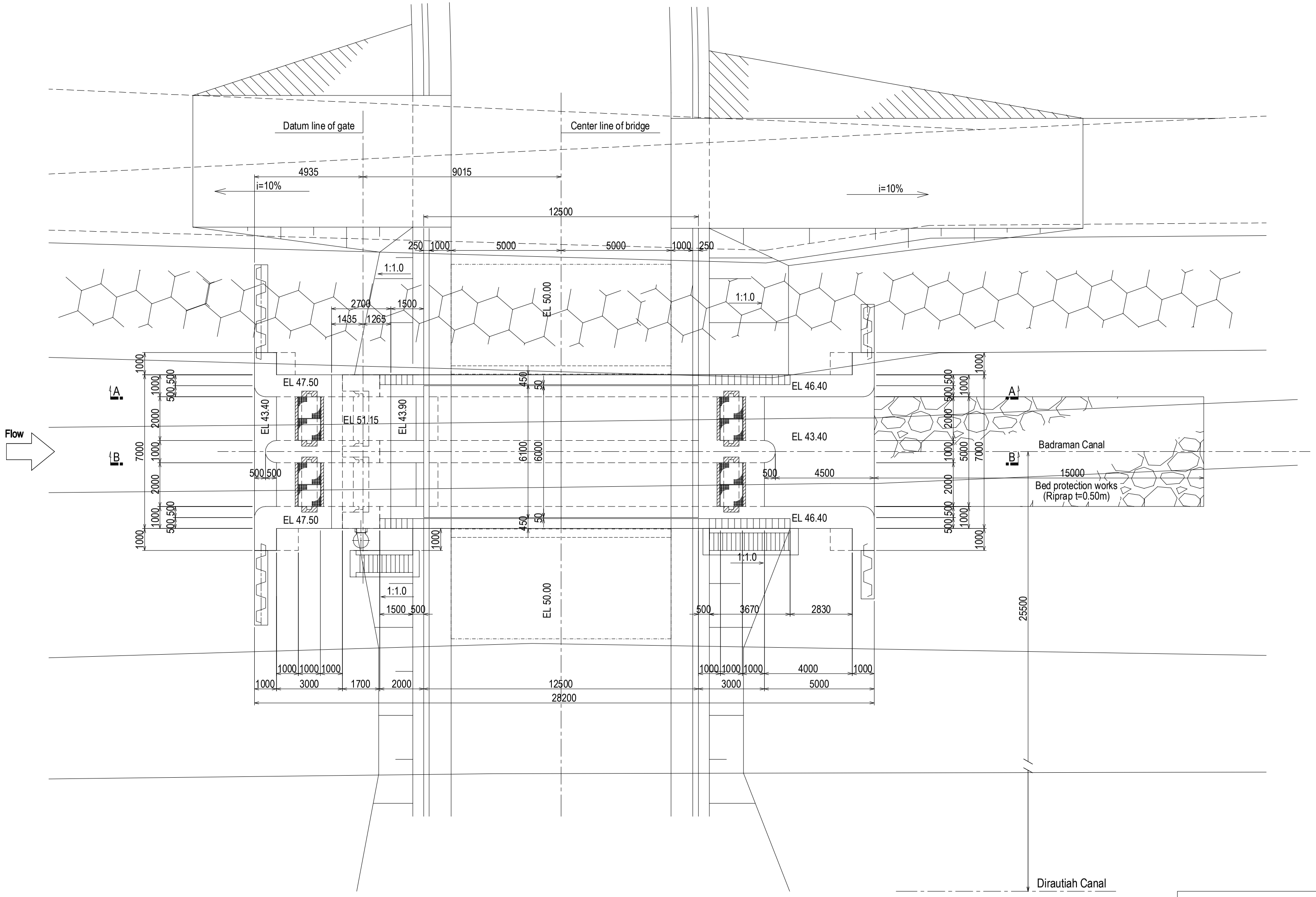
Note;

▨ Shaded area indicates the range of second stage concrete to be placed with steel materials.

Plan of Badraman Regulator（Badraman）



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Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Badraman Regulator（Badraman）
Plan

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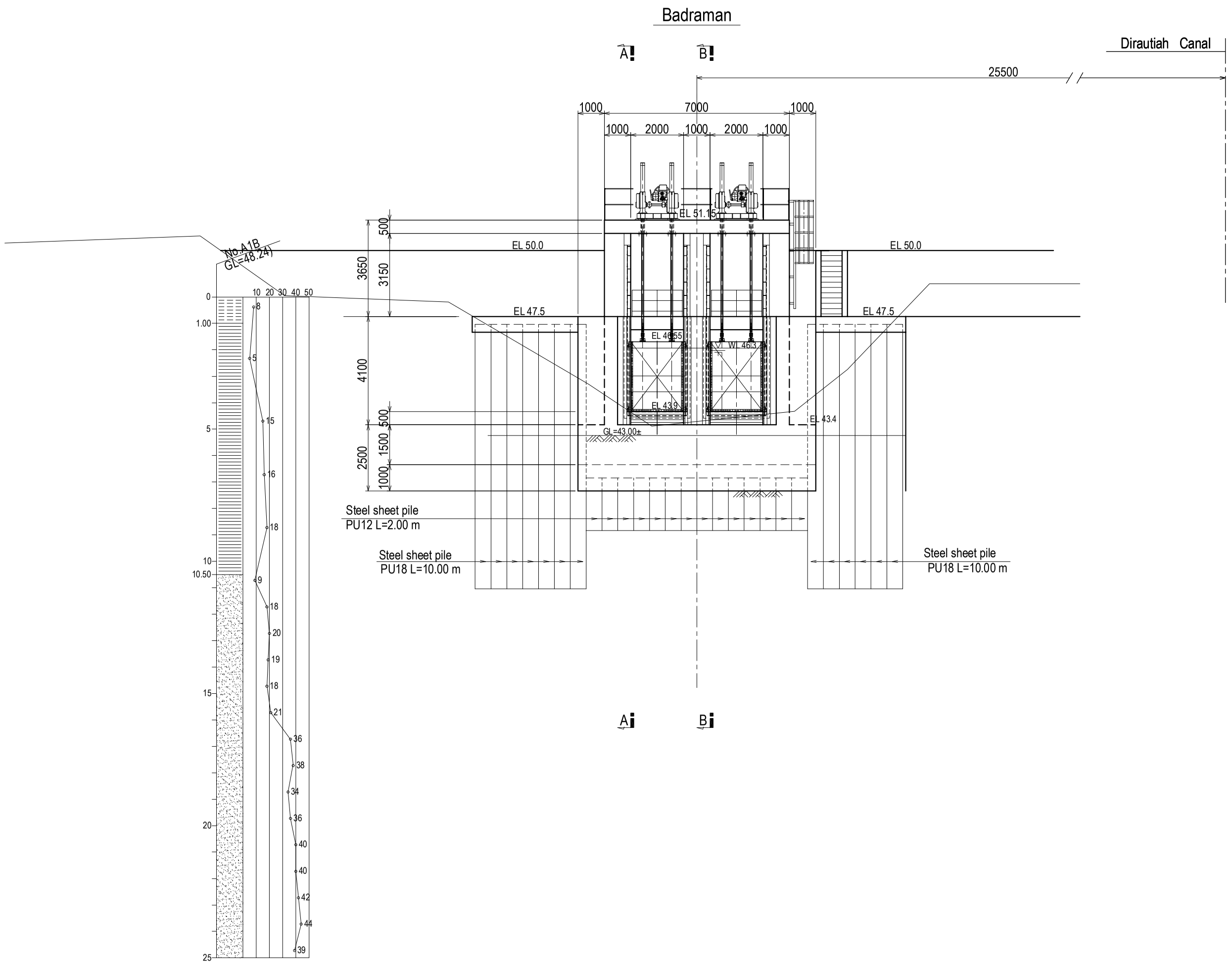
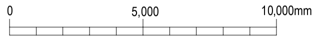
Elevation of Badraman Regulator（Badraman）





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Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Badraman Regulator（Badraman）
Elevation

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CN-2

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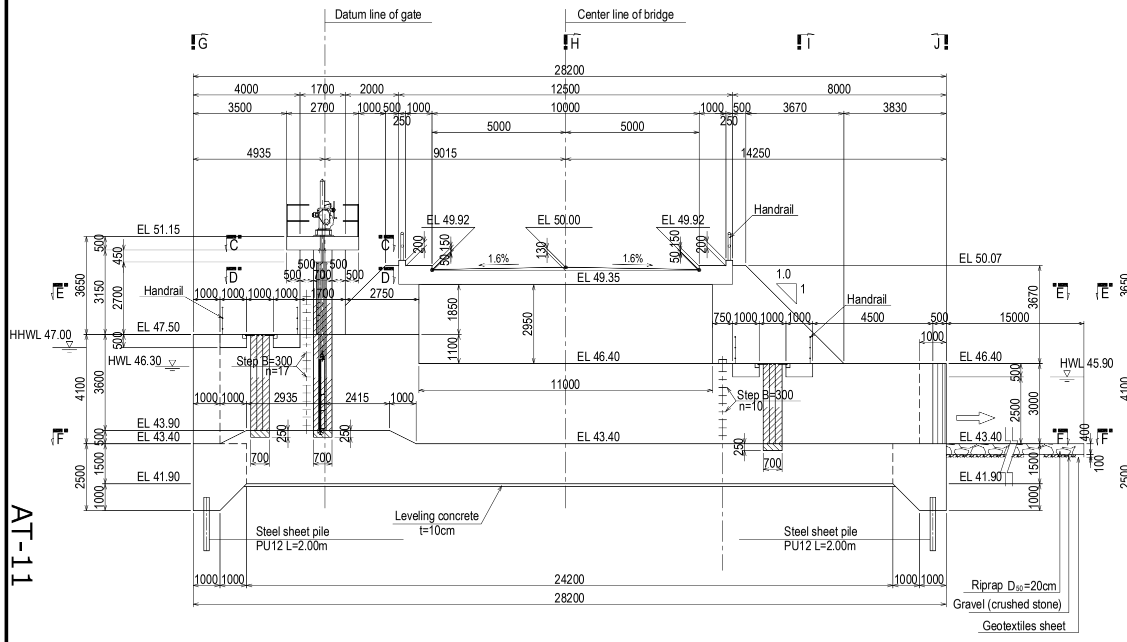
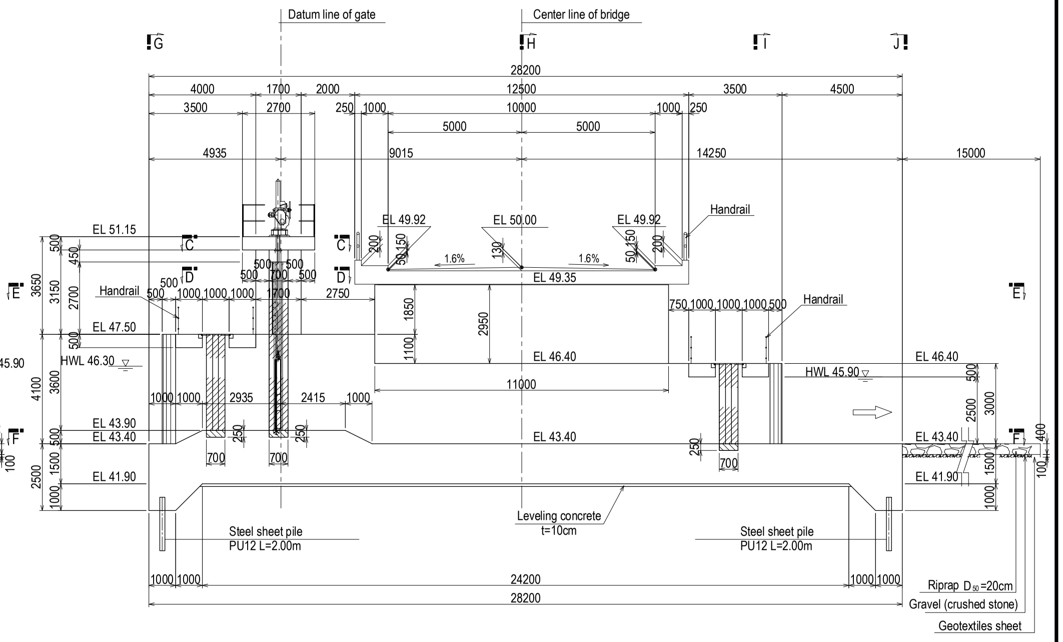
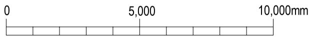
Longitudinal Section of Badraman Regulator（Badraman）

Section A－A



Section B－B





Note;

▨ Shaded area indicates the range of second stage concrete to be placed with steel materials.

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Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Badraman Regulator (Badraman)
Longitudinal section

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CN-3

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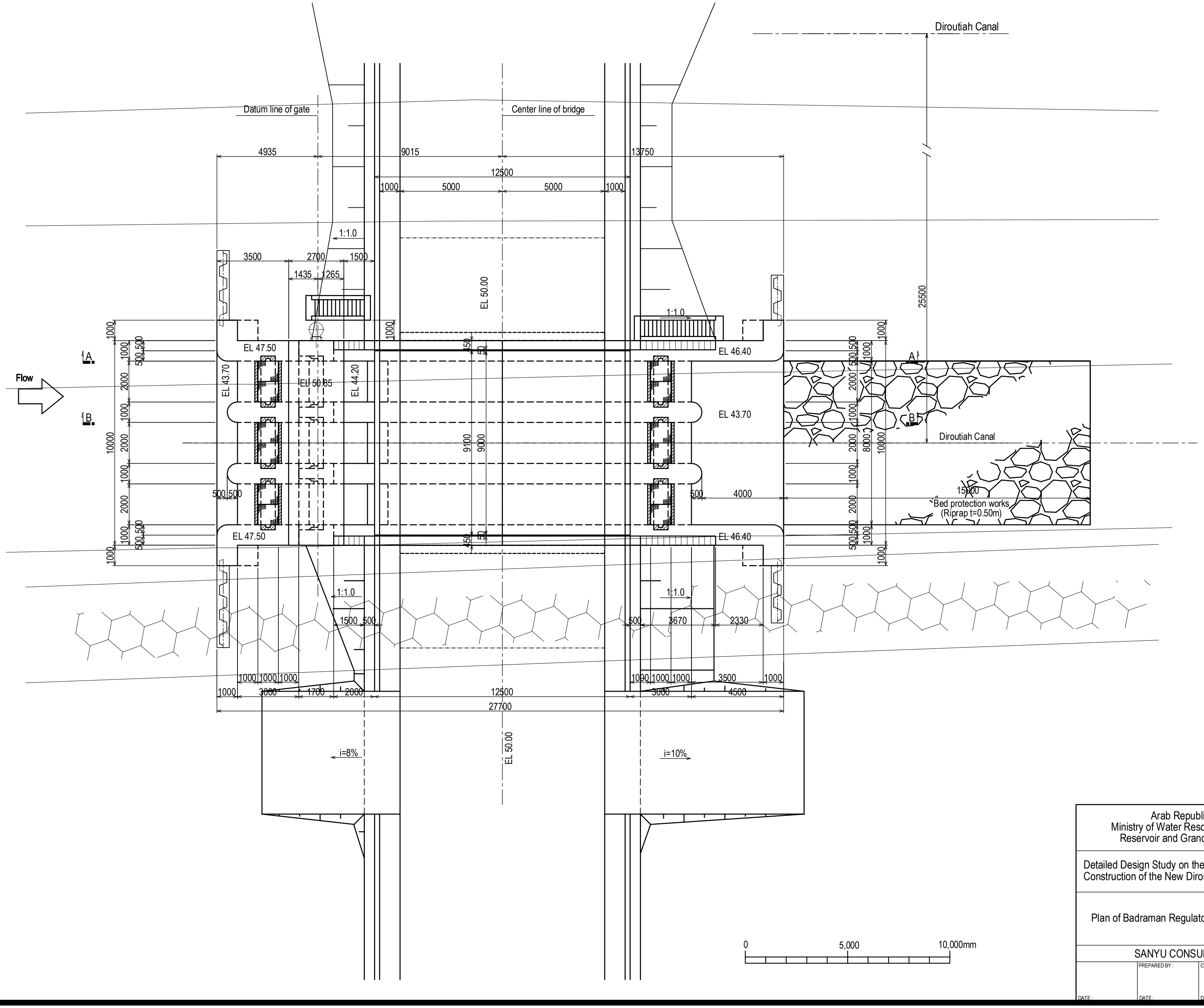
Plan of Badraman Regulator（Diroutiah）



Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Plan of Badraman Regulator（Diroutiah）

DRW. NO.
CD-1

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PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

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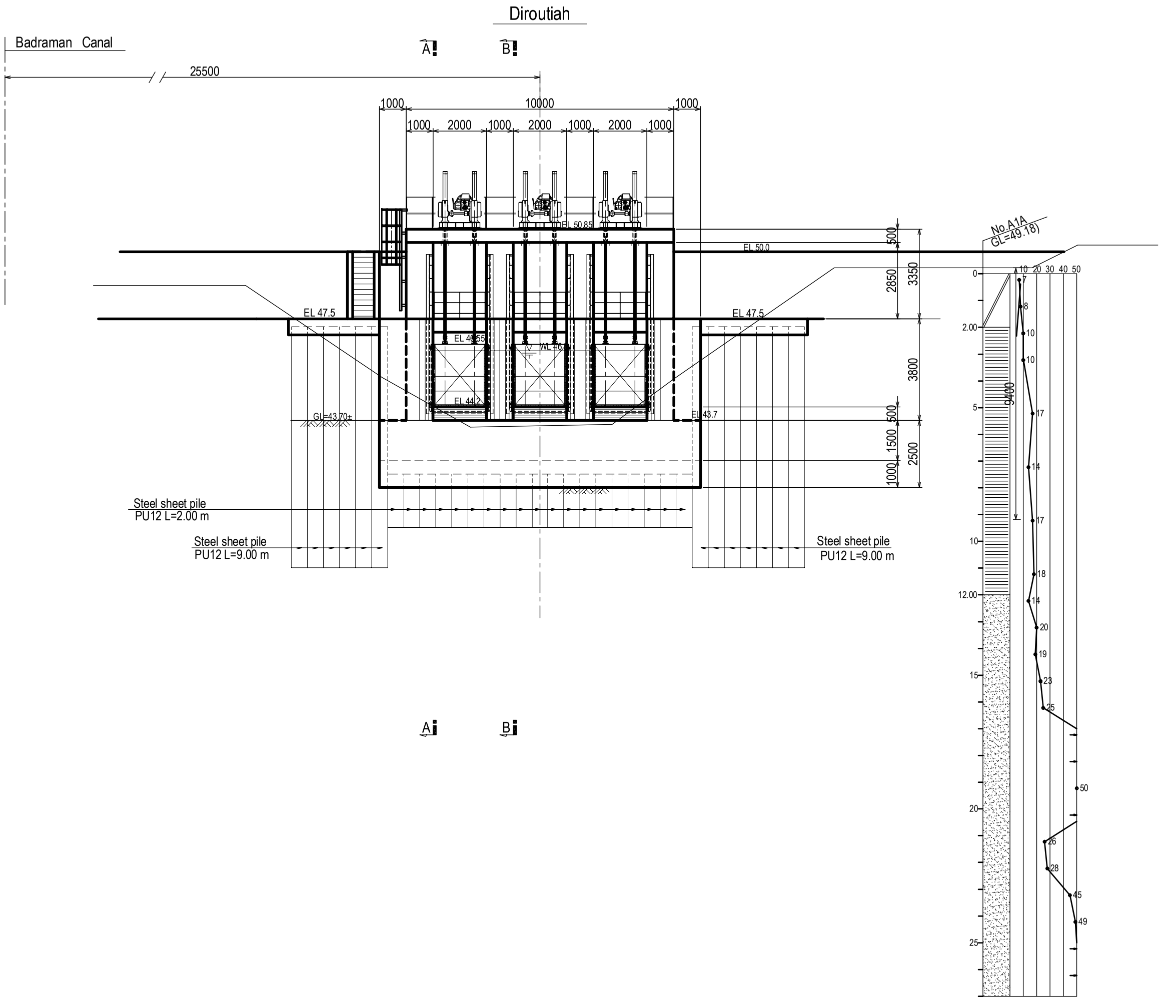
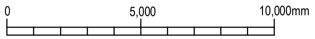
Elevation of Badraman Regulator（Diroutiah）





Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Badraman Regulator（Diroutiah）
Elevation

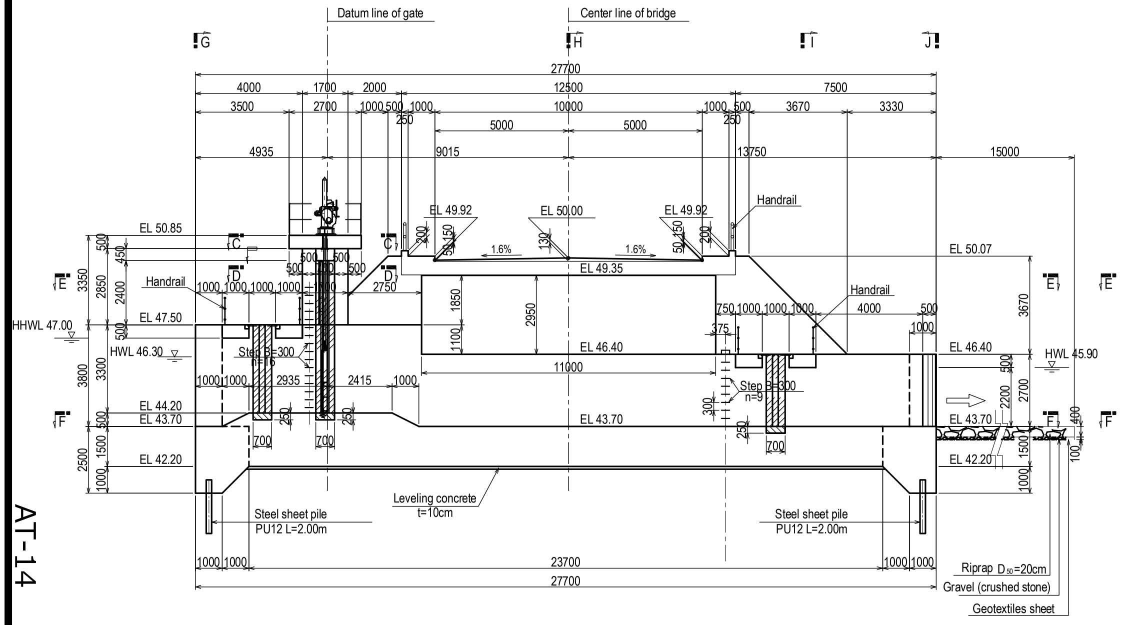
DRW. NO.
CD-2

SANYU CONSULTANTS INC.

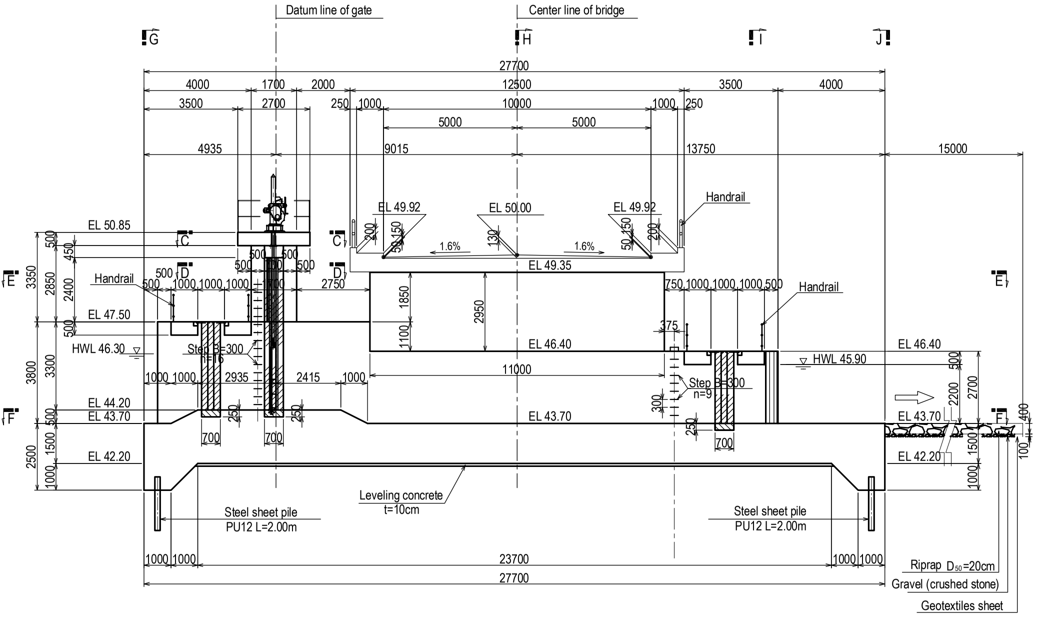
	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

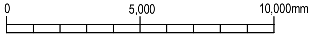
Longitudinal Section of Badraman Regulator（Diroutiah）

Section A—A



Section B—B





Note;

▨ Shaded area indicates the range of second stage concrete to be placed with steel materials.

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

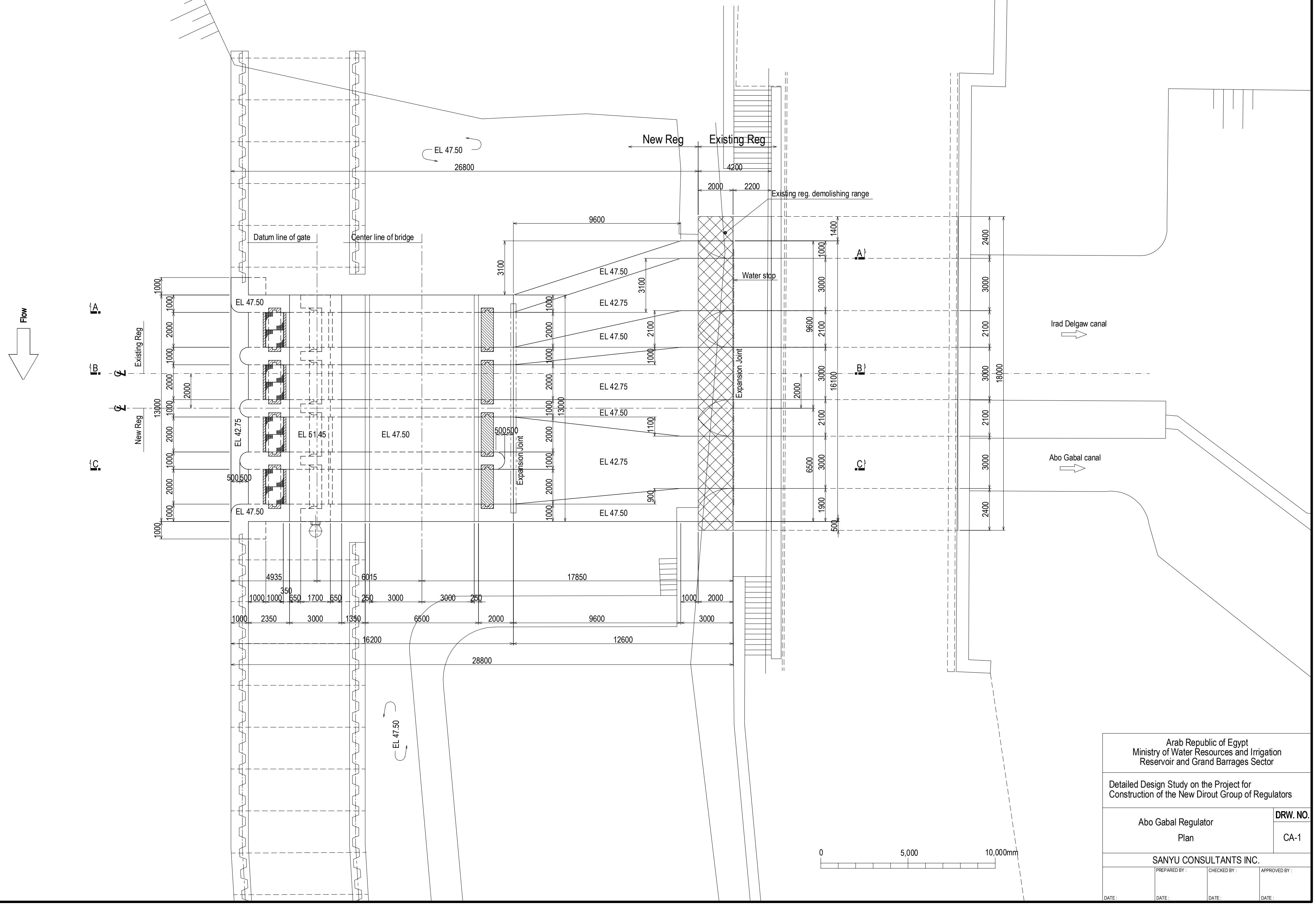
Badraman Regulator（Diroutiah）
Longitudinal section

DRW. NO.
CD-3

SANYU CONSULTANTS INC.

	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

Plan of Abo Gabal Regulator



Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Abo Gabal Regulator
Plan

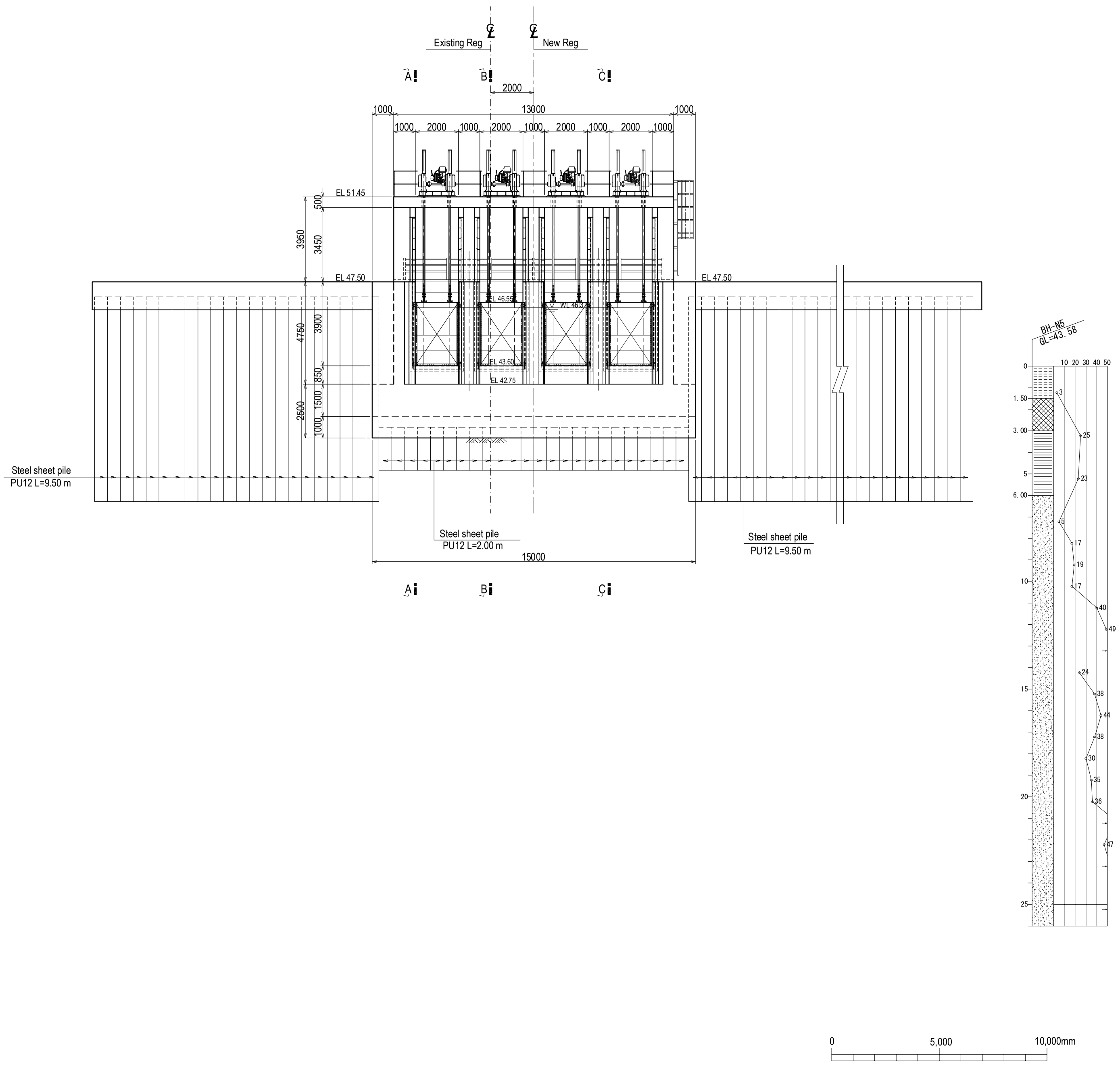
DRW. NO.
CA-1

SANYU CONSULTANTS INC.

PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

DATE :

Elevation of Abo Gabal Regulator



Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

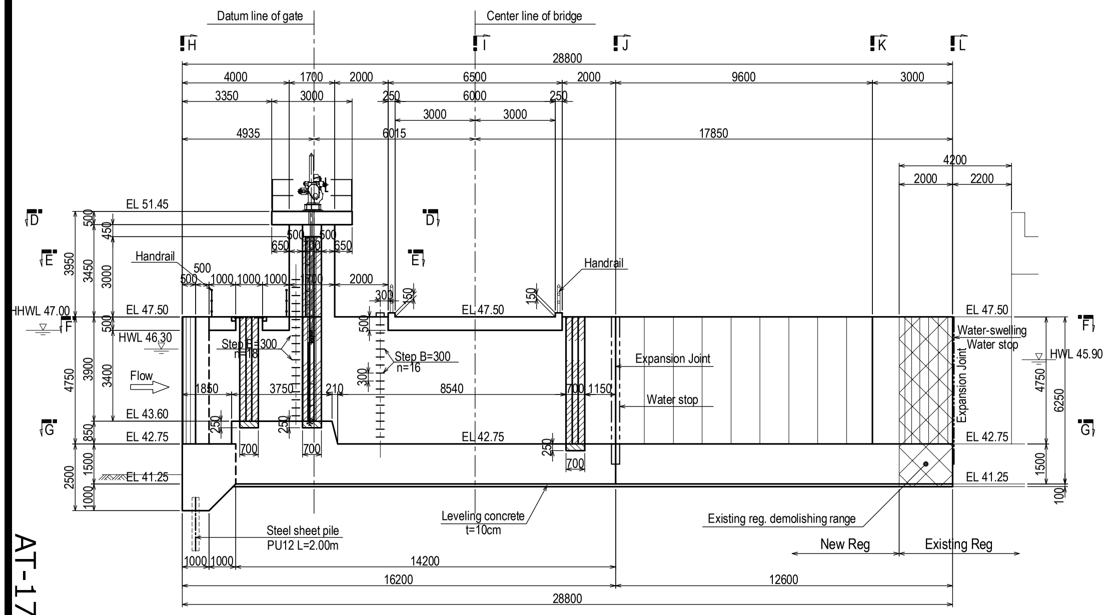
Abo Gabal Regulator Elevation	DRW. NO. CA-2

SANYU CONSULTANTS INC.

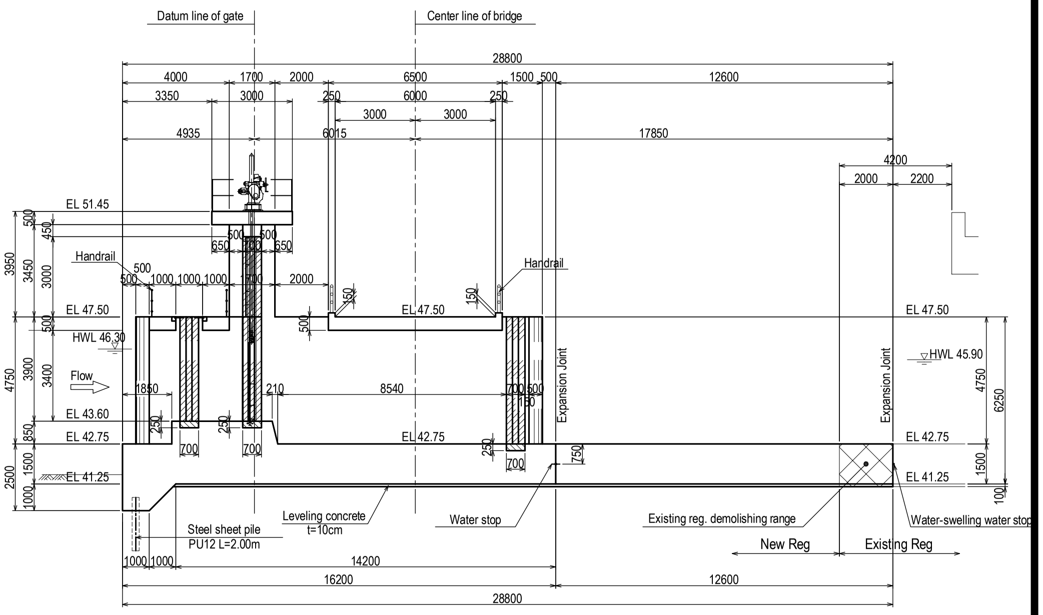
	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

Longitudinal Section of Abo Gabal Regulator

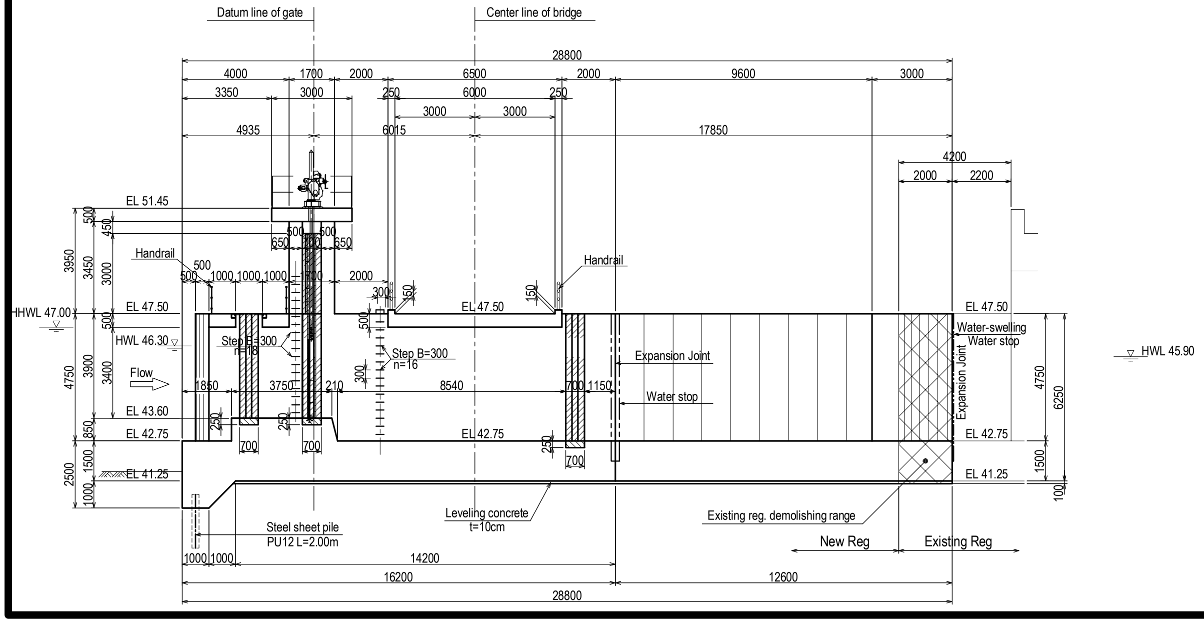
Section A－A

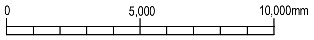


Section C－C



Section B－B





Note;

▨ Shaded area indicates the range of second stage concrete to be placed with steel materials.

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Abo Gabal Regulator
Longitudinal section

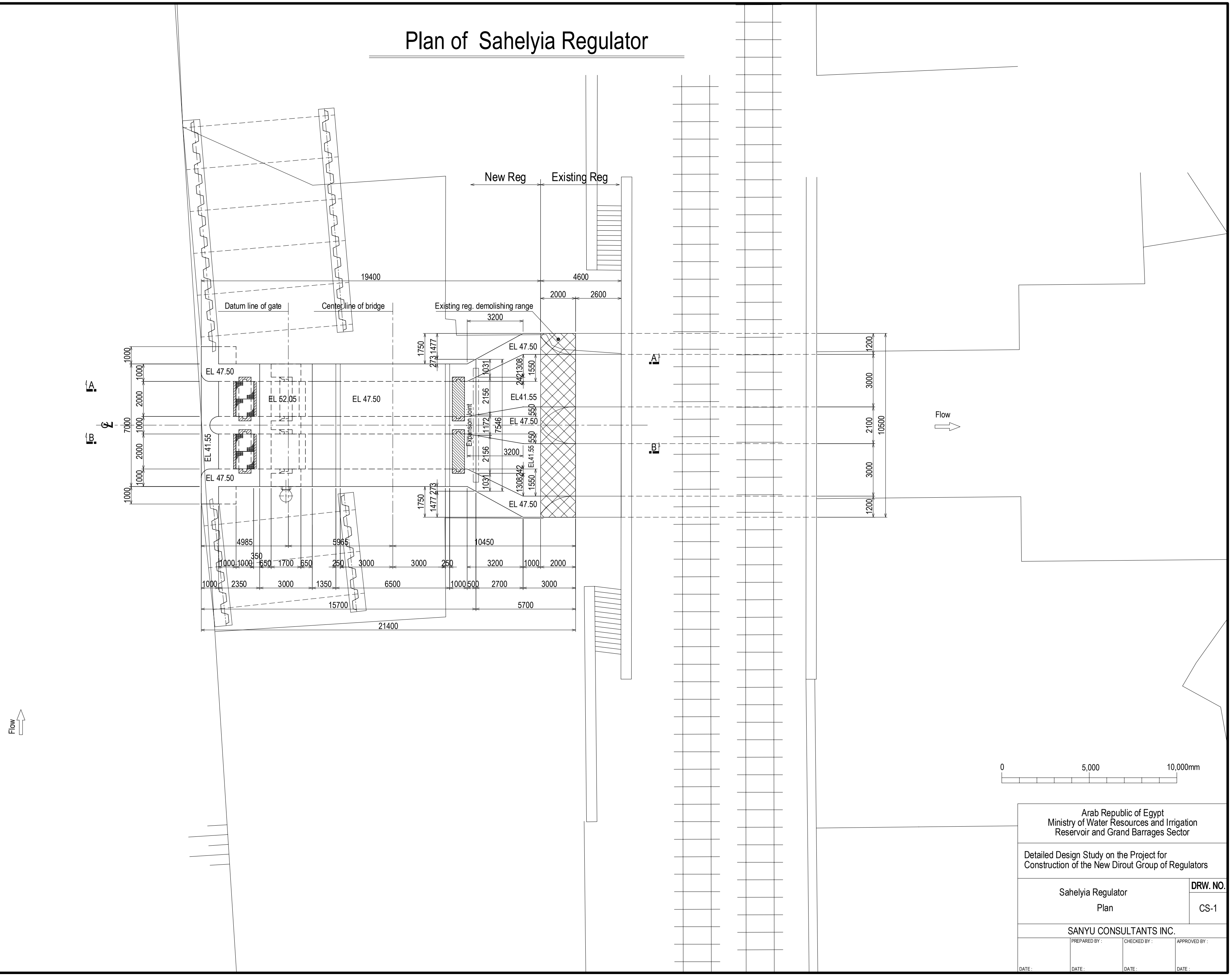
DRW. NO.
CA-3

SANYU CONSULTANTS INC.

PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

DATE :

Plan of Sahelyia Regulator



Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Sahelyia Regulator
Plan

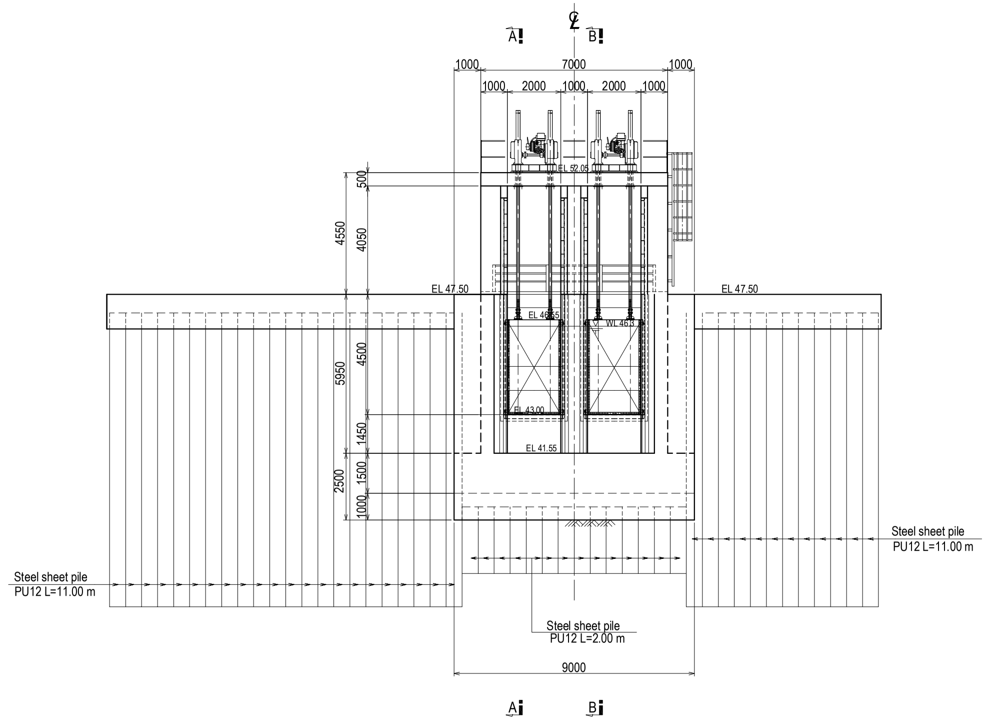
DRW. NO.
CS-1

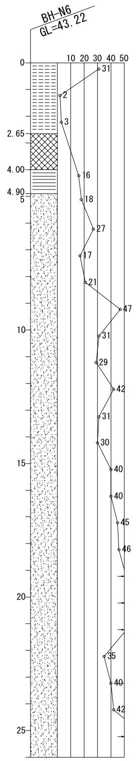
SANYU CONSULTANTS INC.

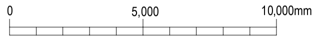
PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

DATE :

Elevation of Sahelyia Regulator







Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Sahelyia Regulator
Elevation

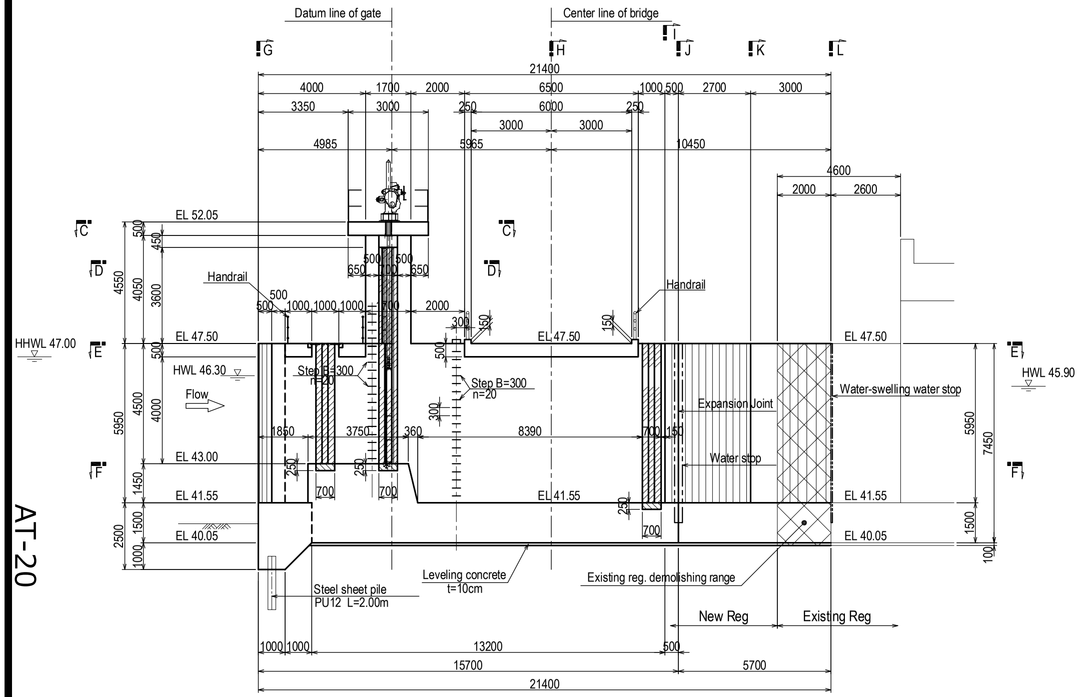
DRW. NO.
CS-2

SANYU CONSULTANTS INC.

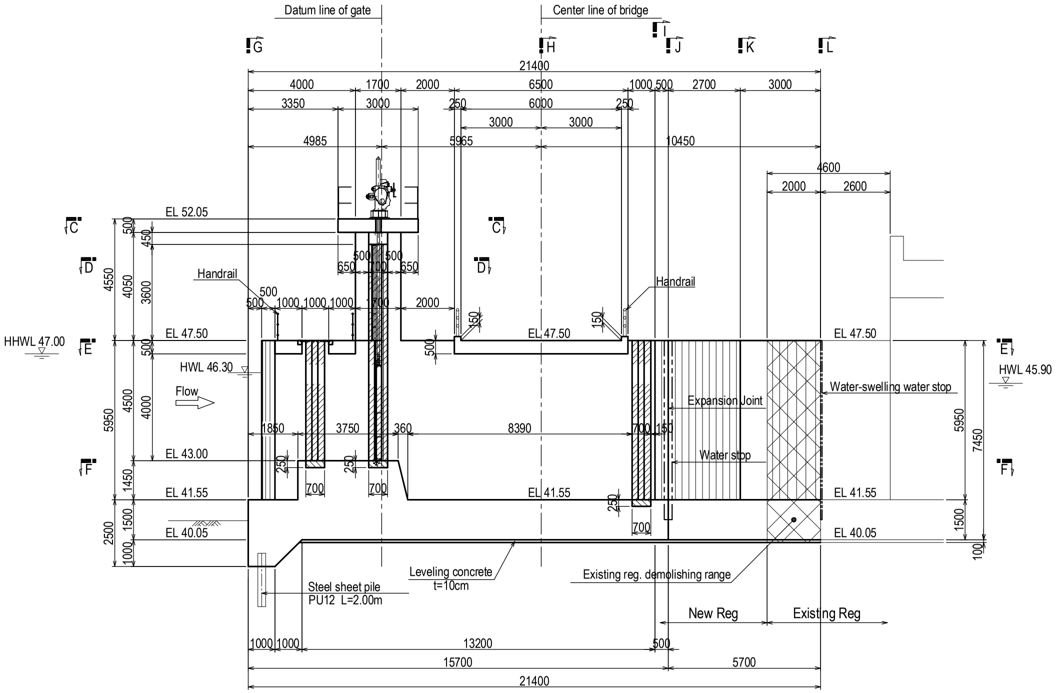
	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

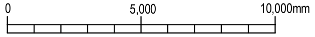
Longitudinal Section of Sahelyia Regulator

Section A—A



Section B—B





Note;

▨ Shaded area indicates the range of second stage concrete to be placed with steel materials.

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Sahelyia Regulator
Longitudinal section

DRW. NO.
CS-3

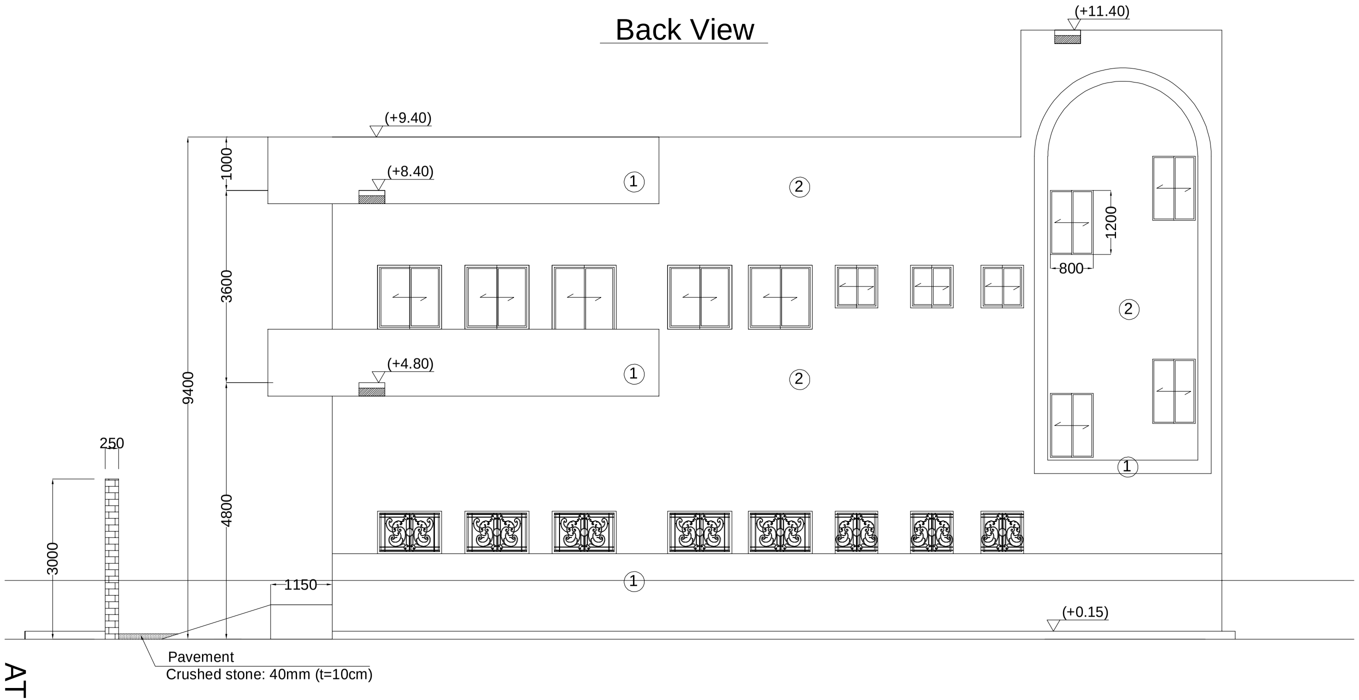
SANYU CONSULTANTS INC.

	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

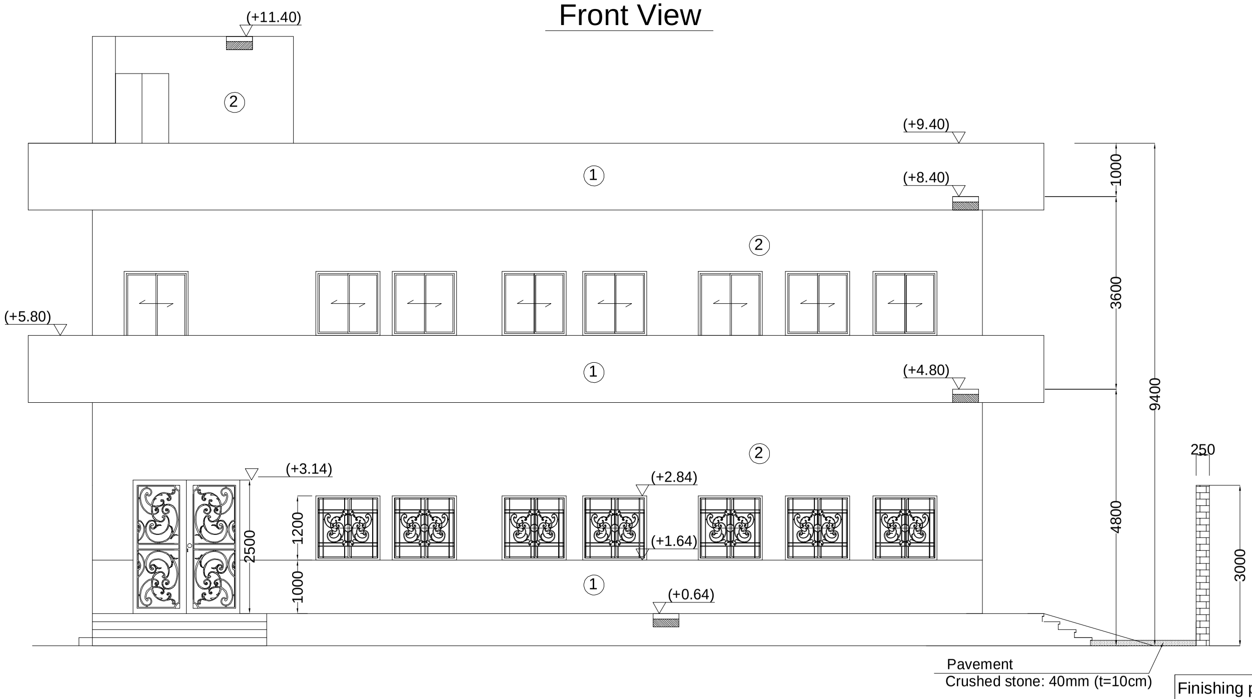
AT-2. Architecture Design of NDGRs

AT-22

Back View



Front View



Notes :
Design Ground Level (± 0.00) is = EL50.20

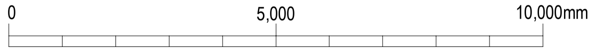


Table of Finishing

Finishing pattern	Finishing Type
①	Plastering : Kimstoon Painting With a requested color
②	Plastering : Kimstoon Painting With a different requested color

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Control house
Views and cross sections(1/2)

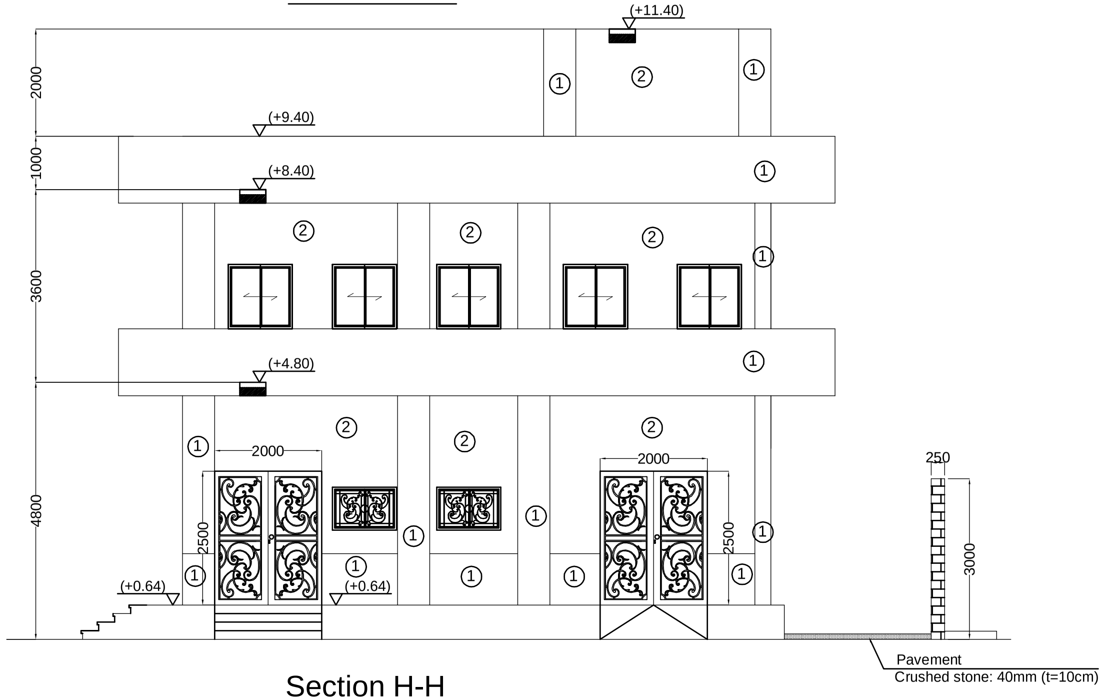
DRW. NO.
AC-3

SANYU CONSULTANTS INC.

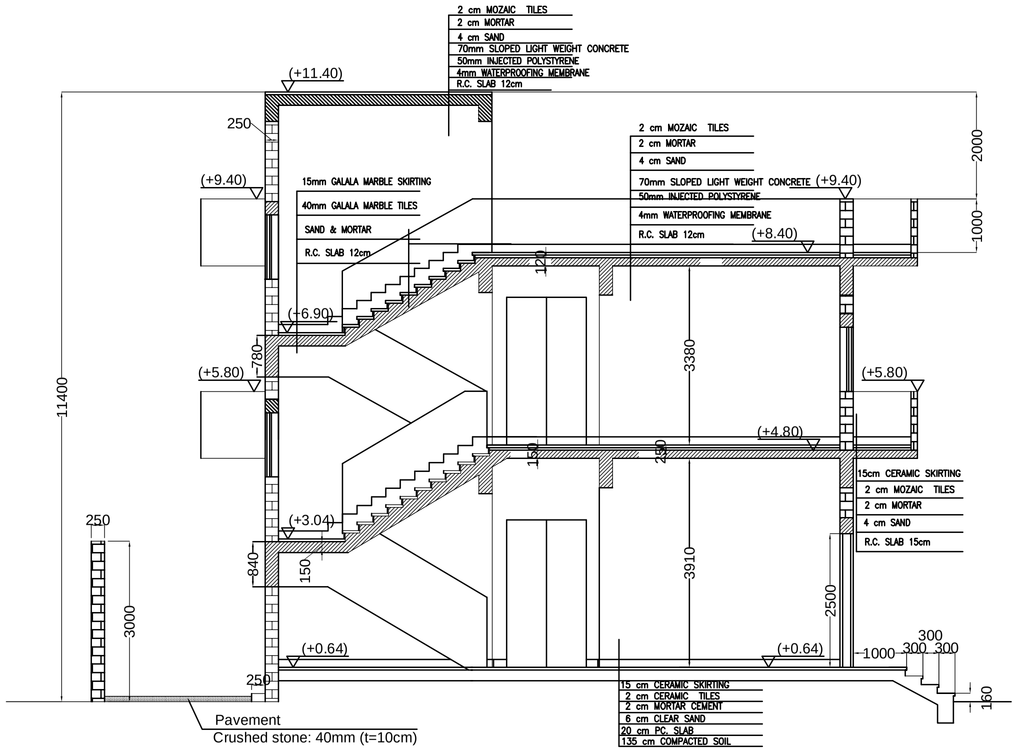
PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

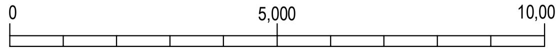
DATE :

Side View



Section H-H





Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Control house
Views and cross sections (2/2)

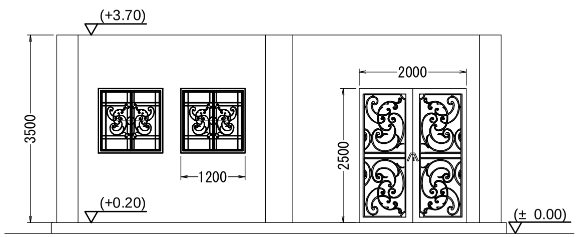
DRW. NO.
AC-4

SANYU CONSULTANTS INC.

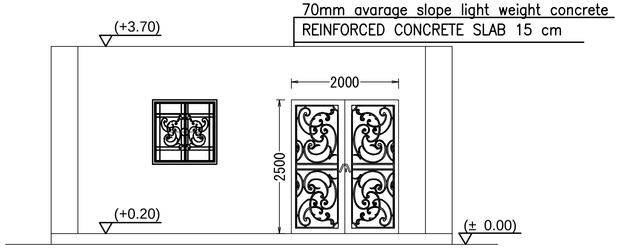
PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

DATE :

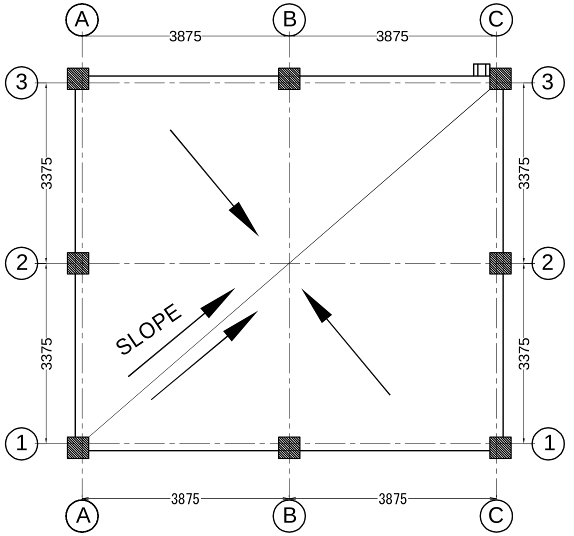
Front View



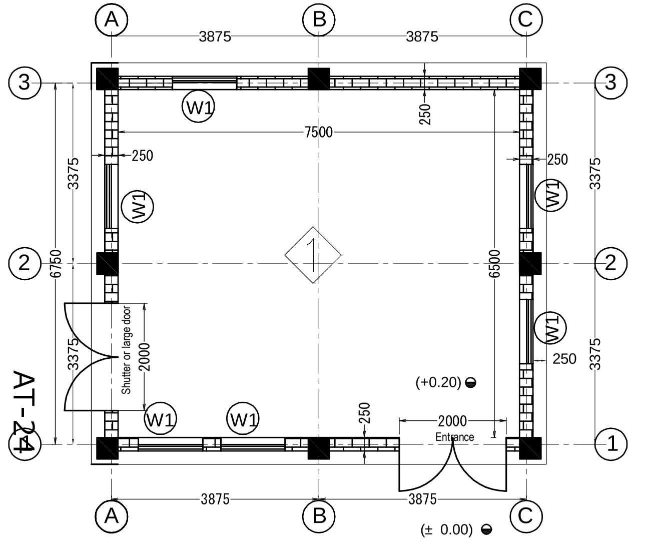
Side View


70mm avarage slope light weight concrete
REINFORCED CONCRETE SLAB 15 cm
(+3.70)
2000
2500
(+0.20)
(± 0.00)

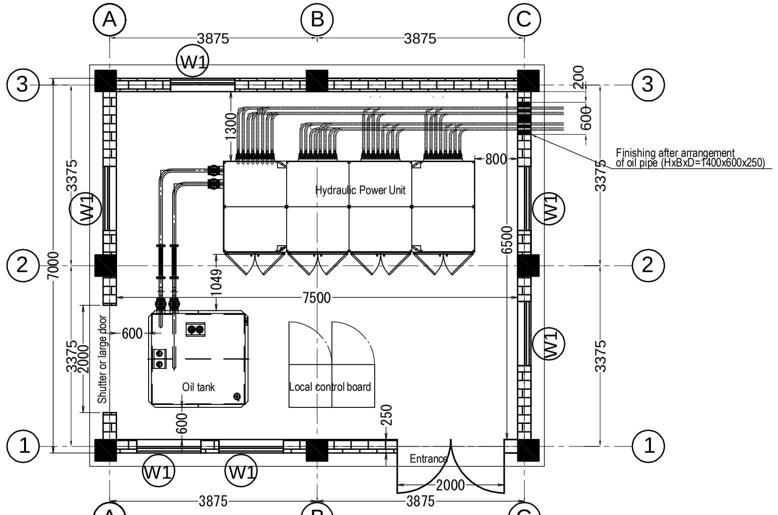
Roof Plan

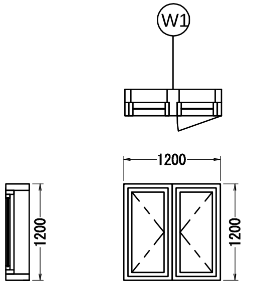


Plan View



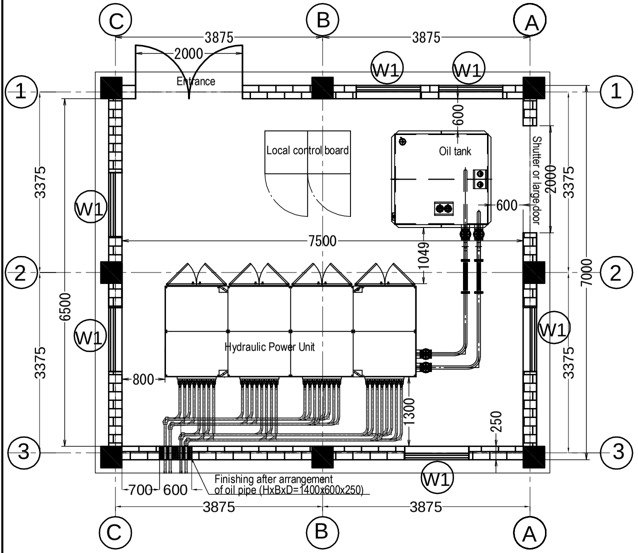
Plan View for BAHR YUSEF





ROOM NO	WINDOW TYPE	NO OF LEAFS	WINDOWS		FRAMES	
			DIMENSIONS (MM)	MATERIAL	TYPE	MATERIAL
1	W1	2	1200*1200	AL	–	ST

Plan View for IBRAHIMIA



Notes :

Design Ground Level (± 0.00)of Ibrahimia is EL46.20

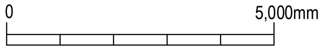
Design Ground Level (± 0.00)of Bahr Yusef is EL47.50

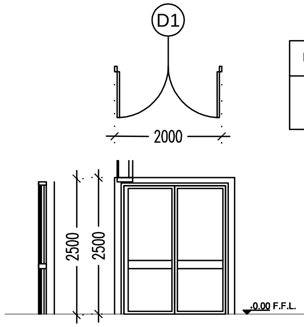
Thickness of wall is 250mm, unless otherwise specified

Legend

▦ Brick wall

■ Reinforce concrete column





Room No.	Room Name	Walls	Floor	Ceiling	Skirting
1	Local control room	Plastering and Painting	Helicopter finished Exposed P. concrete 20 cm Thk.	Plastering and Painting	---------

ROOM NO	DOOR TYPE	NO OF LEAFS	DOORS		FRAMES	
			DIMENSIONS (MM)	MATERIAL	TYPE	MATERIAL
1	D1	-	2000*2500	ST	–	ST

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Local control house
General layout

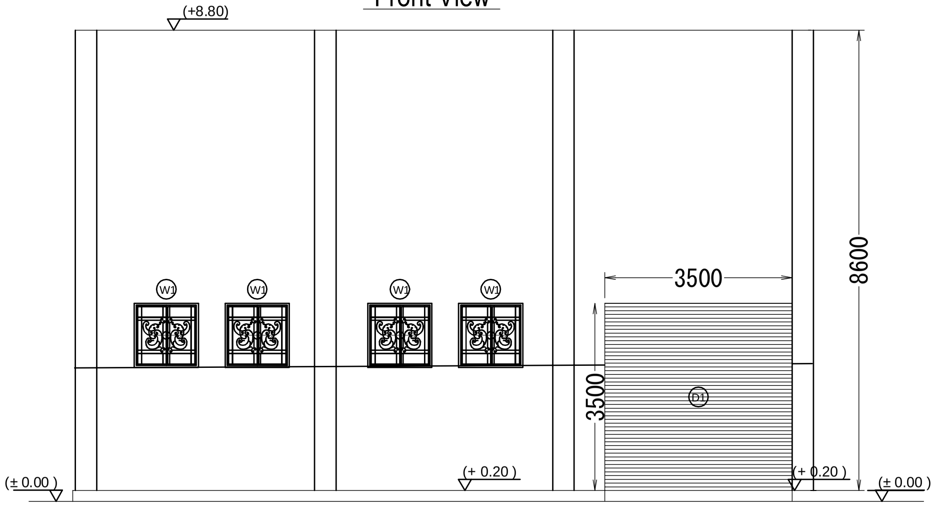
DRW. NO.
AL-1

SANYU CONSULTANTS INC.

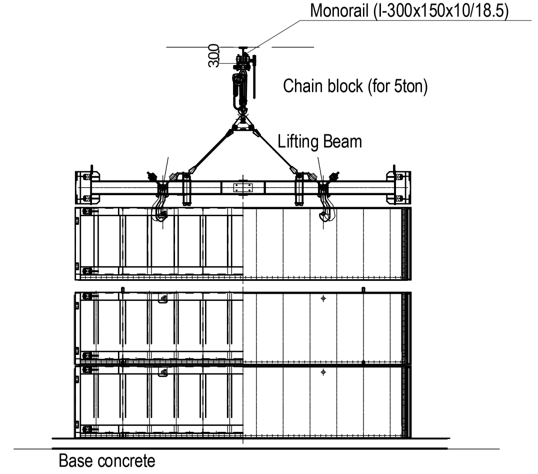
PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

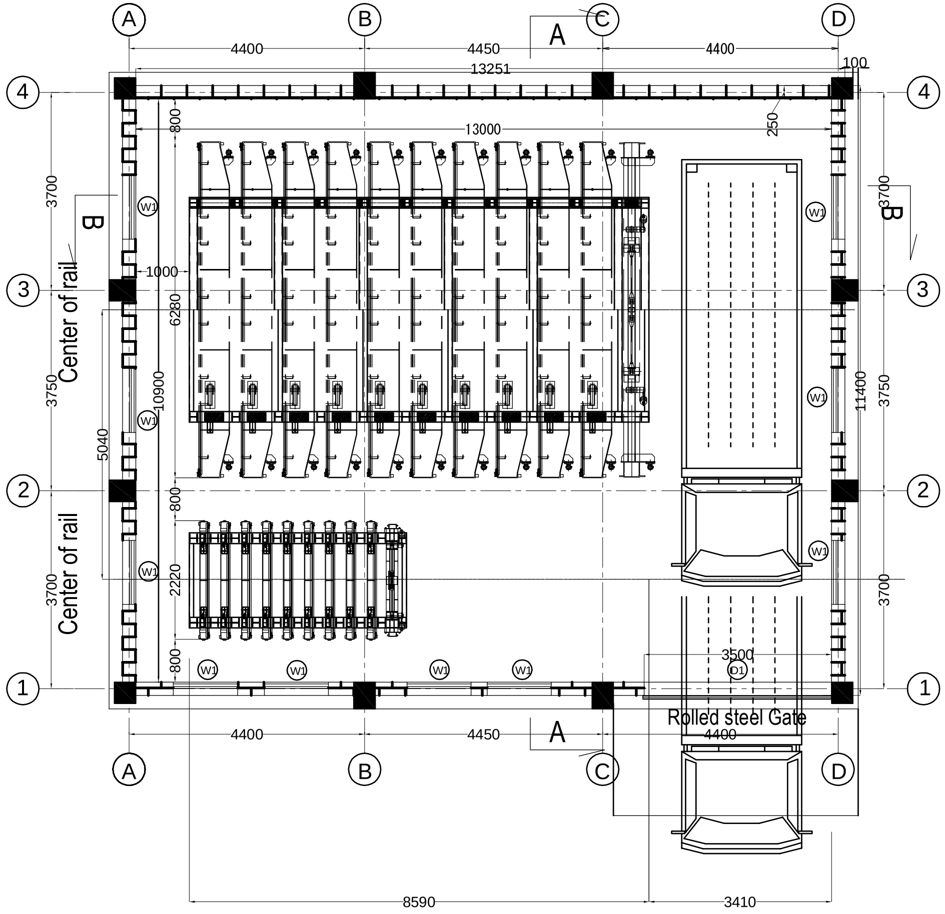
DATE :

Front View

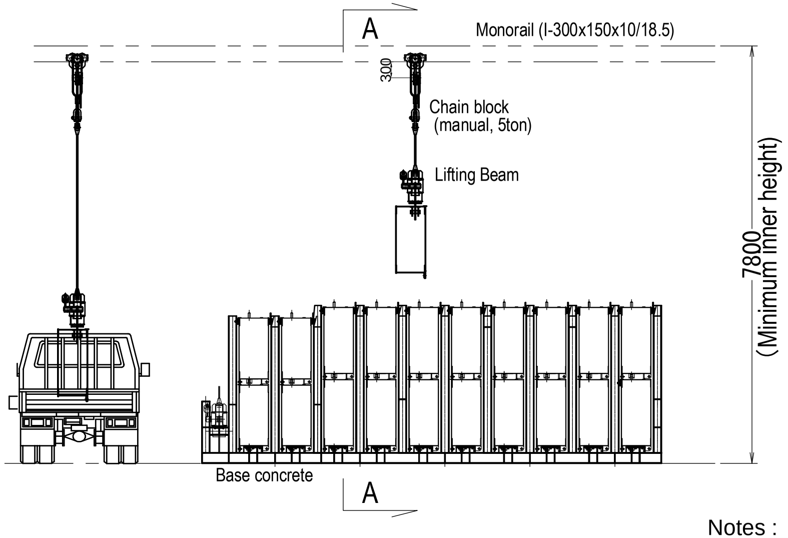


Section A-A





Section B-B



Notes :

Design Ground Level (± 0.00) is = EL50.20

Legend

▤	Brick wall
■	Reinforce concrete column

0 5,000mm

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Stop log house
Views and cross sections

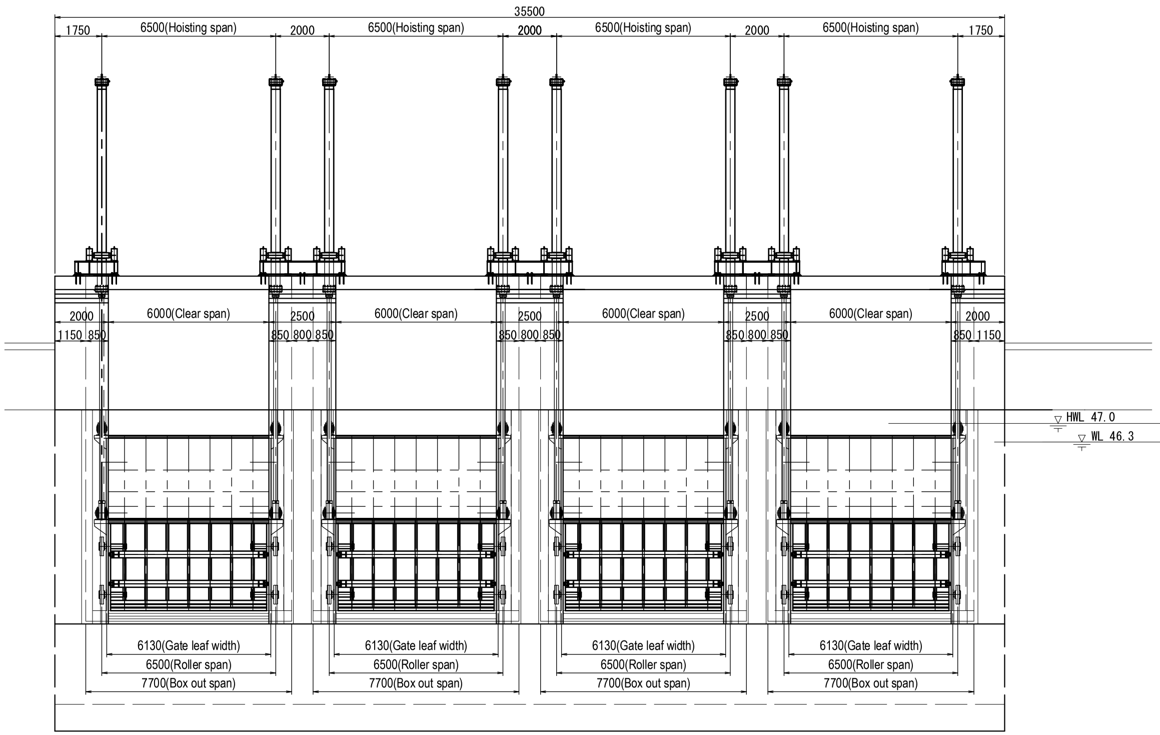
DRW. NO.
AS-1

SANYU CONSULTANTS INC.

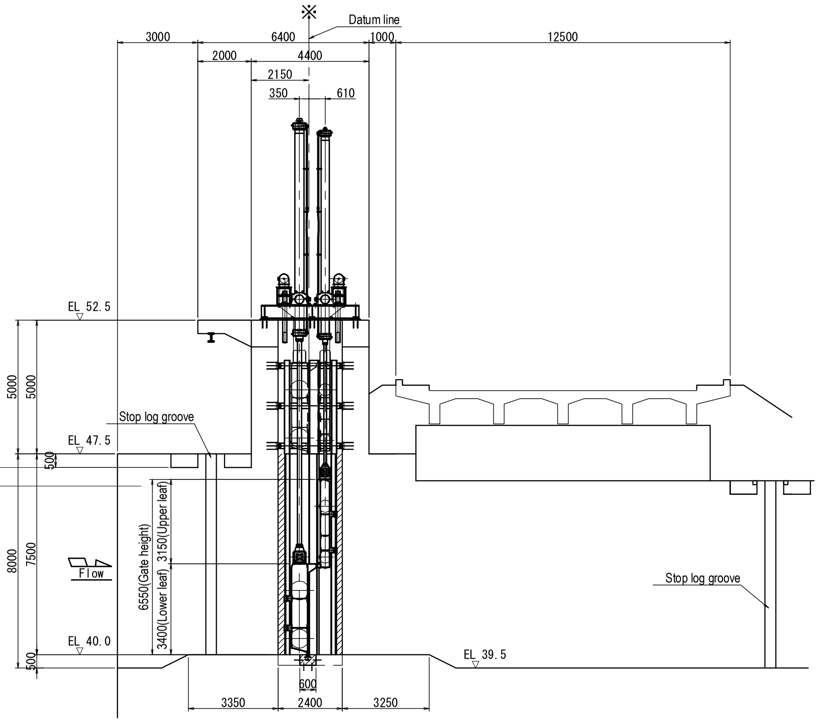
	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

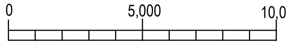
AT-3. Mechanical and Electric Works for Gate

Front elevation



Side view





Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Bahr Yusef & Ibrahimia Regulator
General drawing

DRW. NO
MBI-1

SANYU CONSULTANTS INC.

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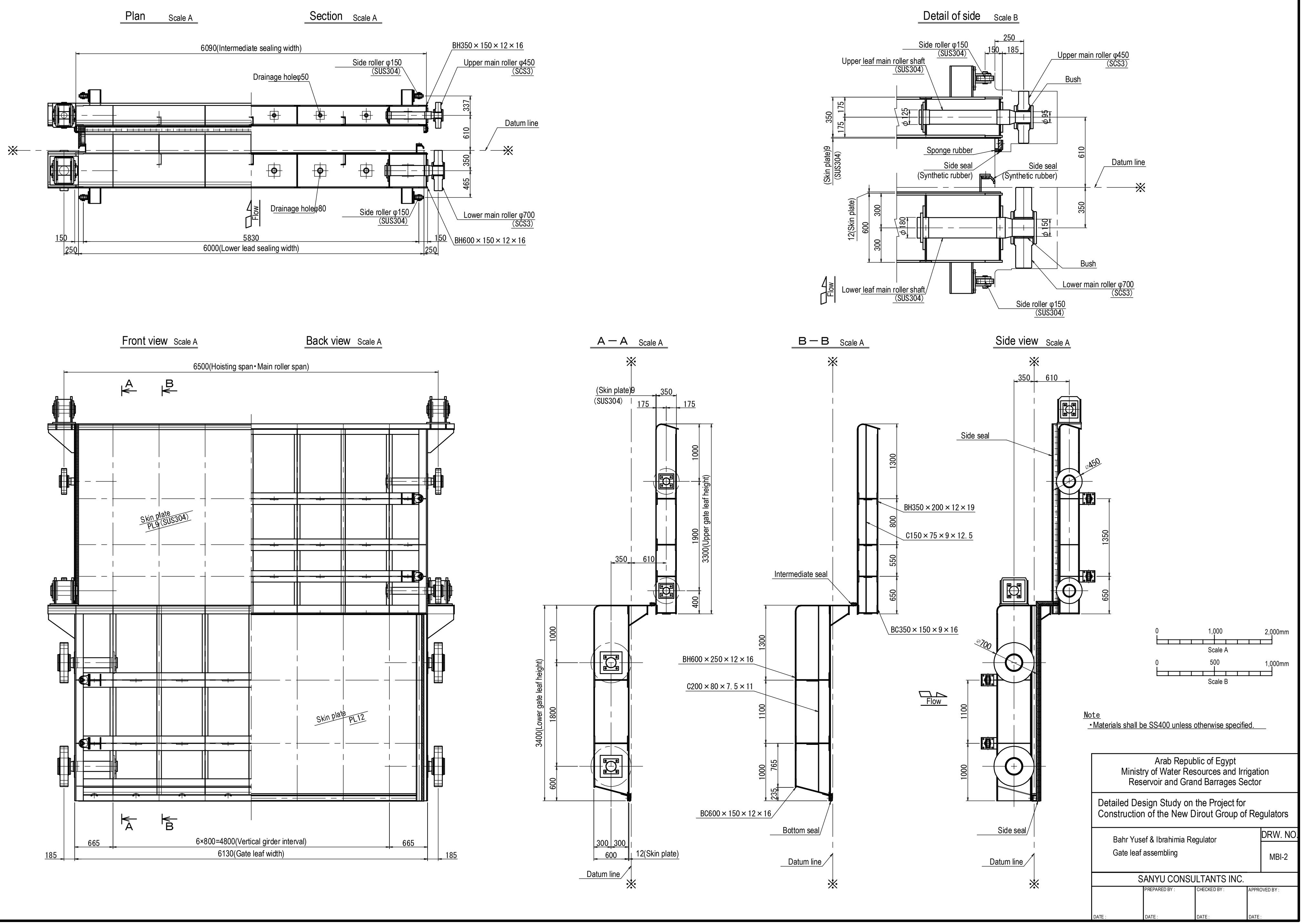
DATE :	DATE :	DATE :	DATE :



Note
・Materials shall be SS400 unless otherwise specified.

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

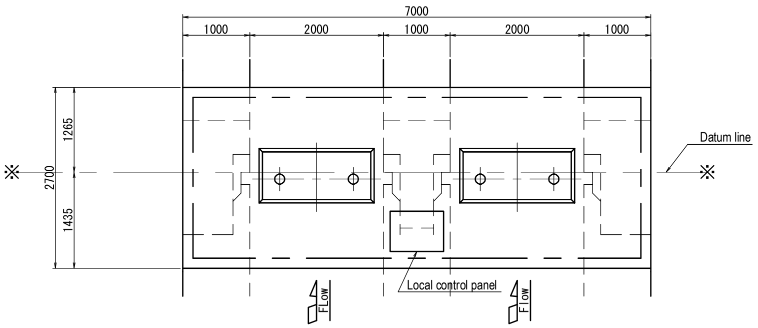
Bahr Yusef & Ibrahimia Regulator
Gate leaf assembling

DRW. NO.
MBI-2

SANYU CONSULTANTS INC.

DATE :	PREPARED BY : DATE :	CHECKED BY : DATE :	APPROVED BY : DATE :

Plan

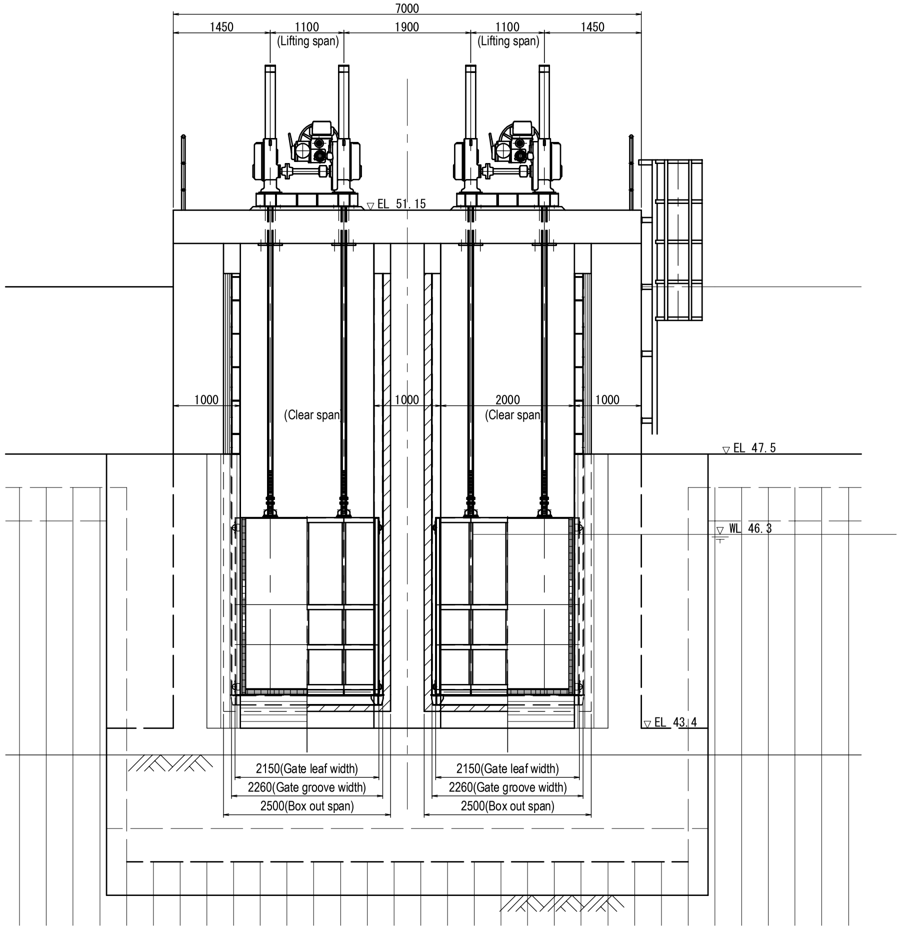


Design Condition

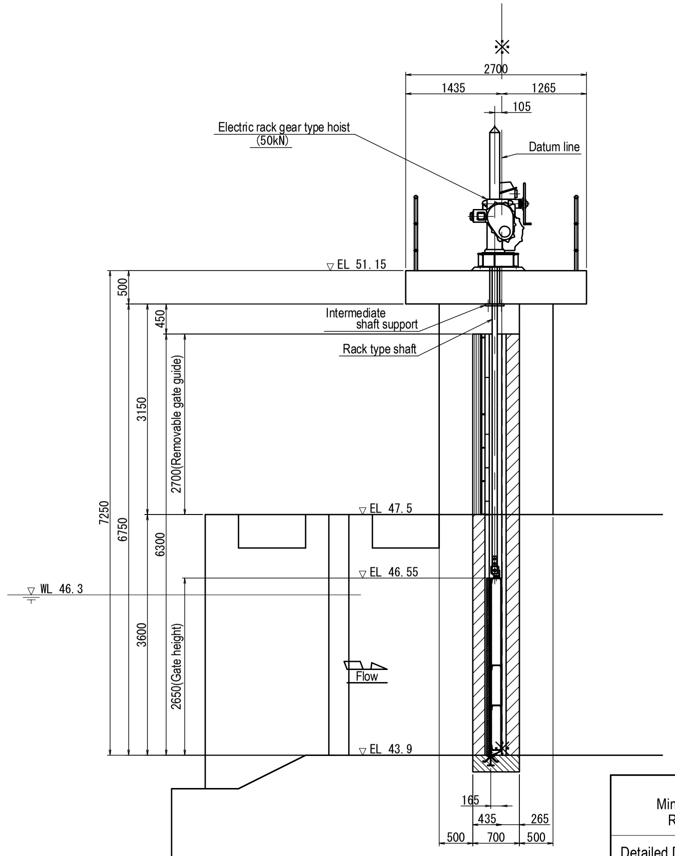
Type	Slide gate	
Number of gate	2	
Clear span	2.000 m	
Gate height	2.650 m	
Design water depth	2.650 m	
Operation depth	Open	2.650 m
	Close	2.650 m
Sediment height	0.300 m	
Seal type	Upstream 3-side sealing	
Hoist type	Electric rack gear type	
Operating speed	0.3 m/min	
Lifting height	3.600 m	
Operation type	Local and remote control	

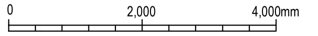
Front elevation

Badraman



Side view





Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Badraman Regulator (Badraman)
General drawing

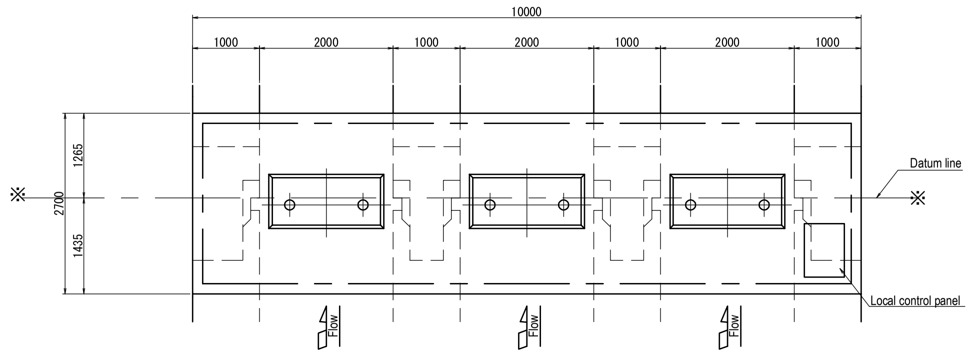
DRW. NO
MN-1

SANYU CONSULTANTS INC.

PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

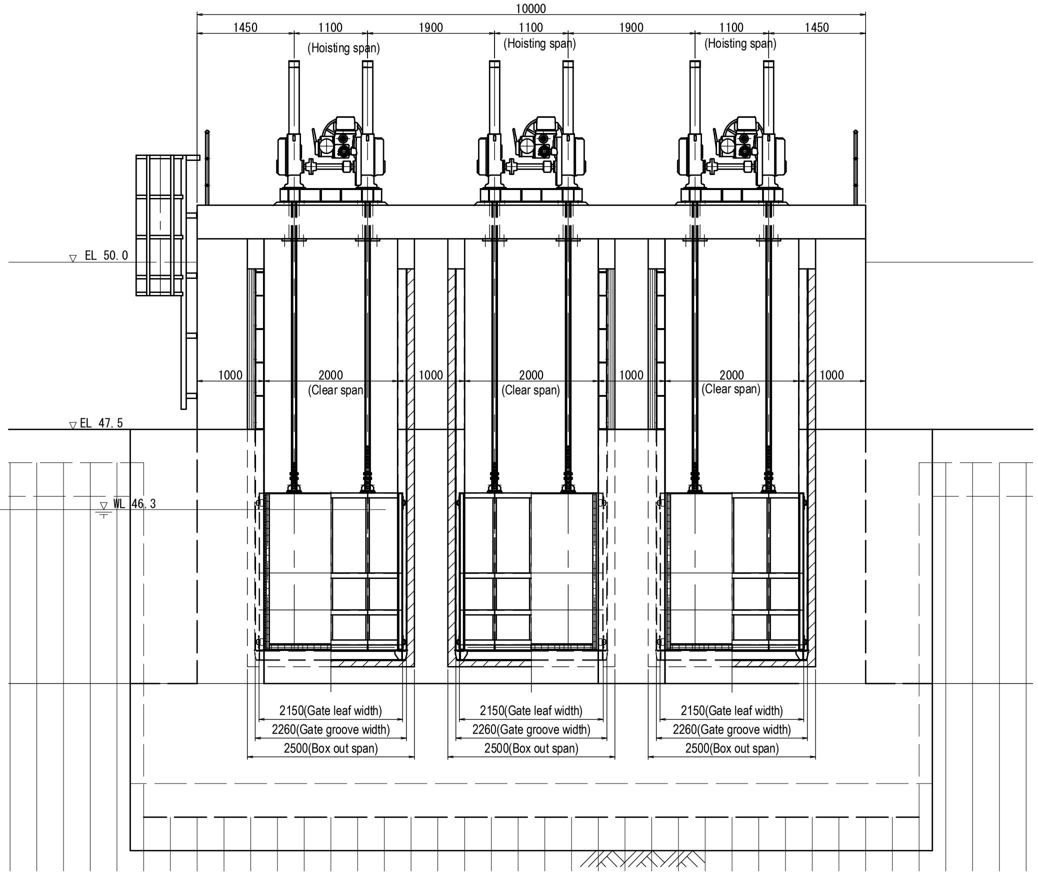
DATE :

Plan



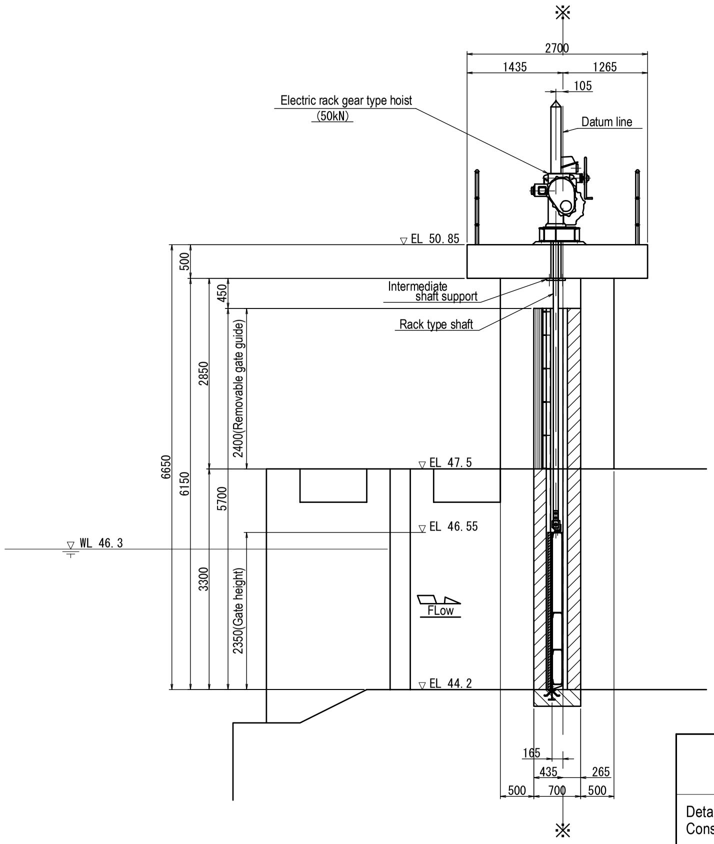
Front view

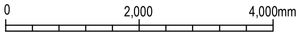
Dirautiah



Design Condition		
Type	Slide gate	
Number of gate	3	
Clear span	2.000 m	
Gate height	2.350 m	
Design water depth	2.350 m	
Operation depth	Open	2.350 m
	Close	2.350 m
Sediment height	0.300 m	
Seal type	Upstream 3-side sealing	
Hoist type	Electric rack gear type	
Operating speed	0.3 m/min	
Lifting height	3.300 m	
Operation type	Local and remote control	

Side view





Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Badraman Regulator (Diroutiah)
General drawing

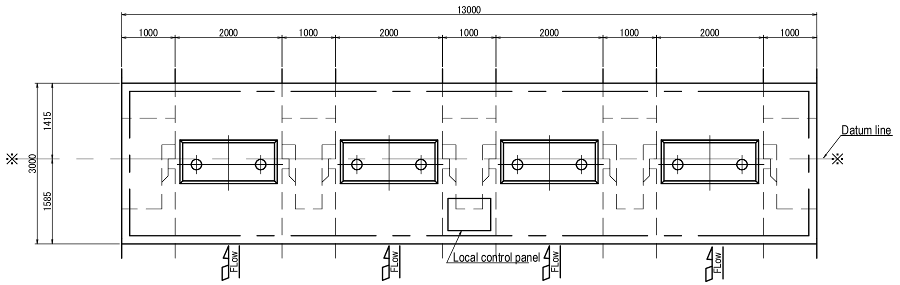
DRW. NO
MD-1

SANYU CONSULTANTS INC.

PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

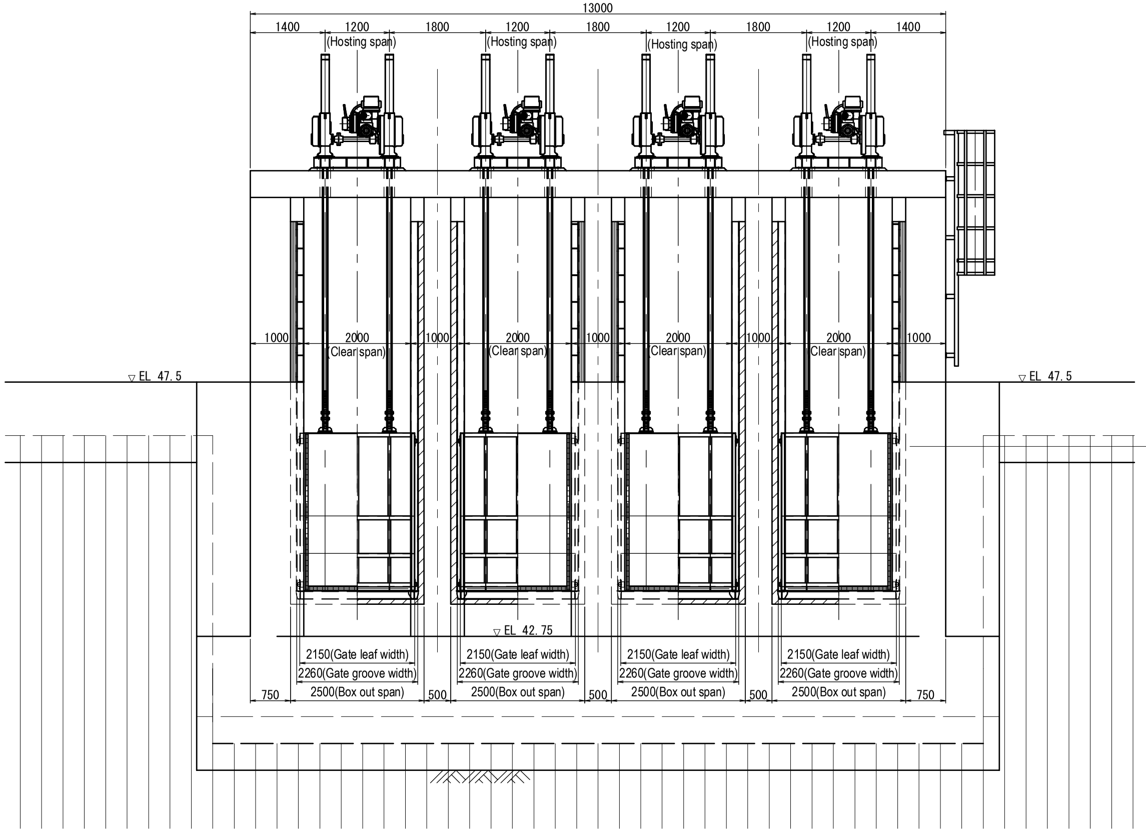
DATE :

Plan

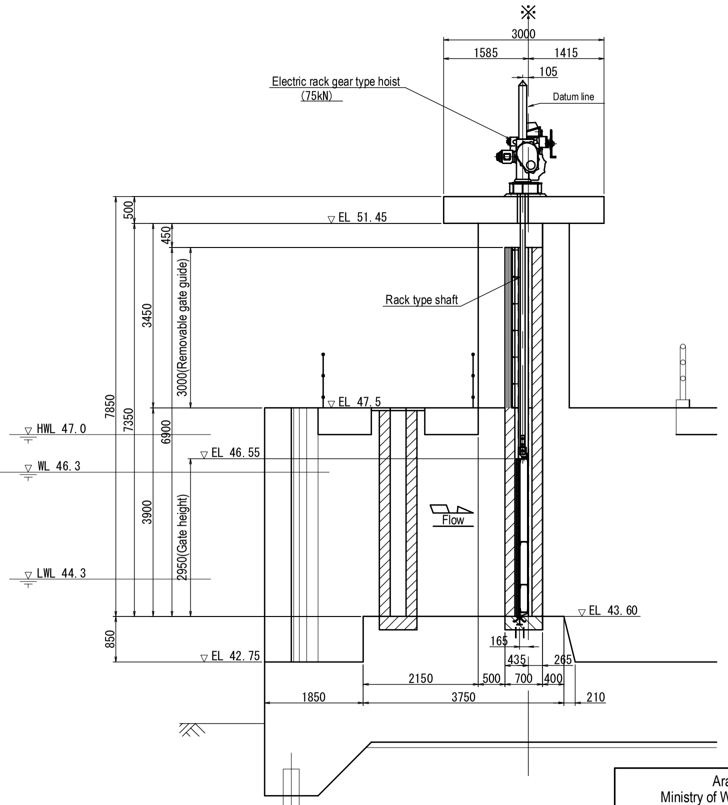


Design Condition		
Type		Slide gate
Number of gate		4
Clear span		2.000 m
Gate height		2.950 m
Design water depth		2.950 m
Operation depth	Open	2.950 m
	Close	2.950 m
Sediment height		0.300 m
Seal type		Upstream 3-side sealing
Hoist type		Electric rack gear type
Operating speed		0.3 m/min
Lifting height		3.900 m
Operation type		Local and remote control

Front elevation



Side view



0 2,000 4,000mm

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Abo Gabal Regulator
General drawing

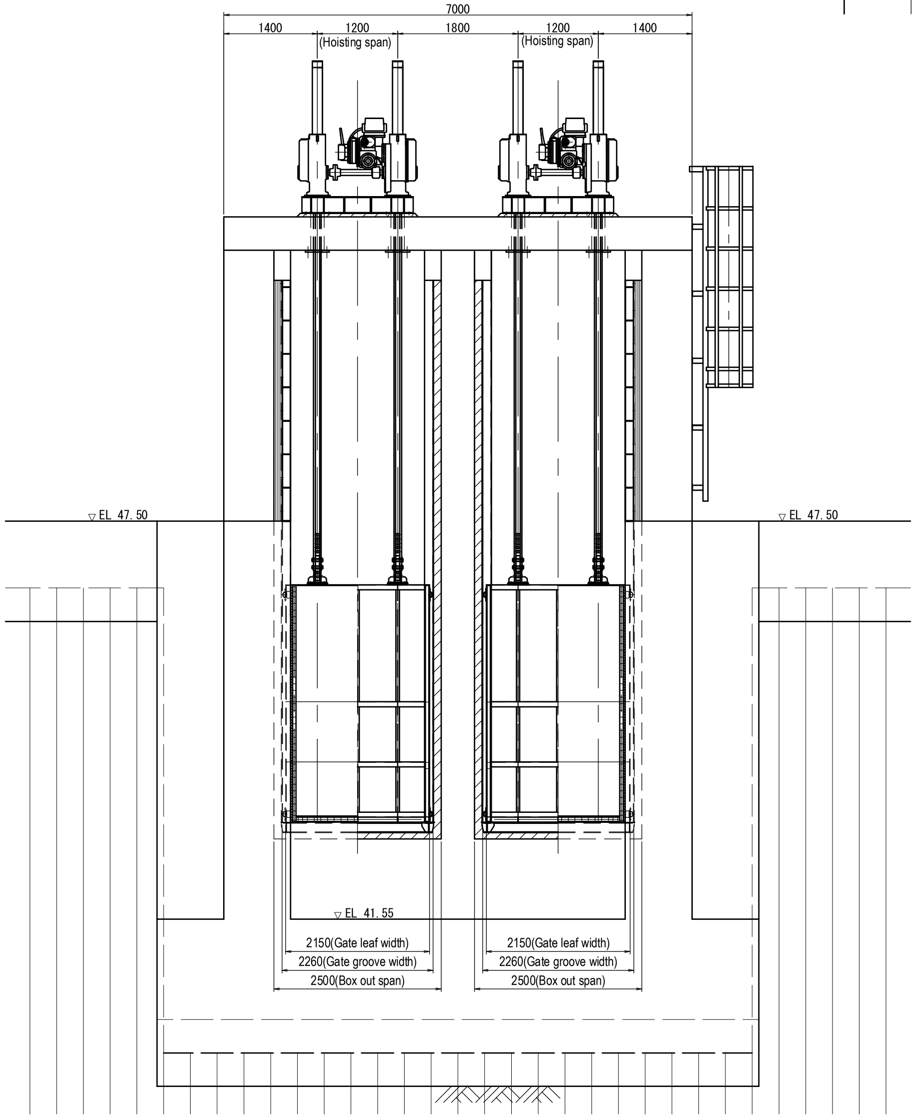
DRW. NO
MA-1

SANYU CONSULTANTS INC.

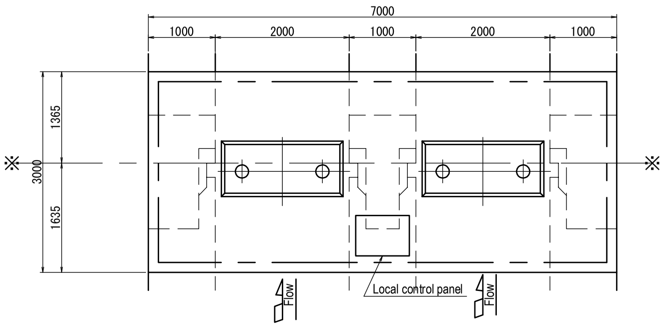
PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :

DATE :

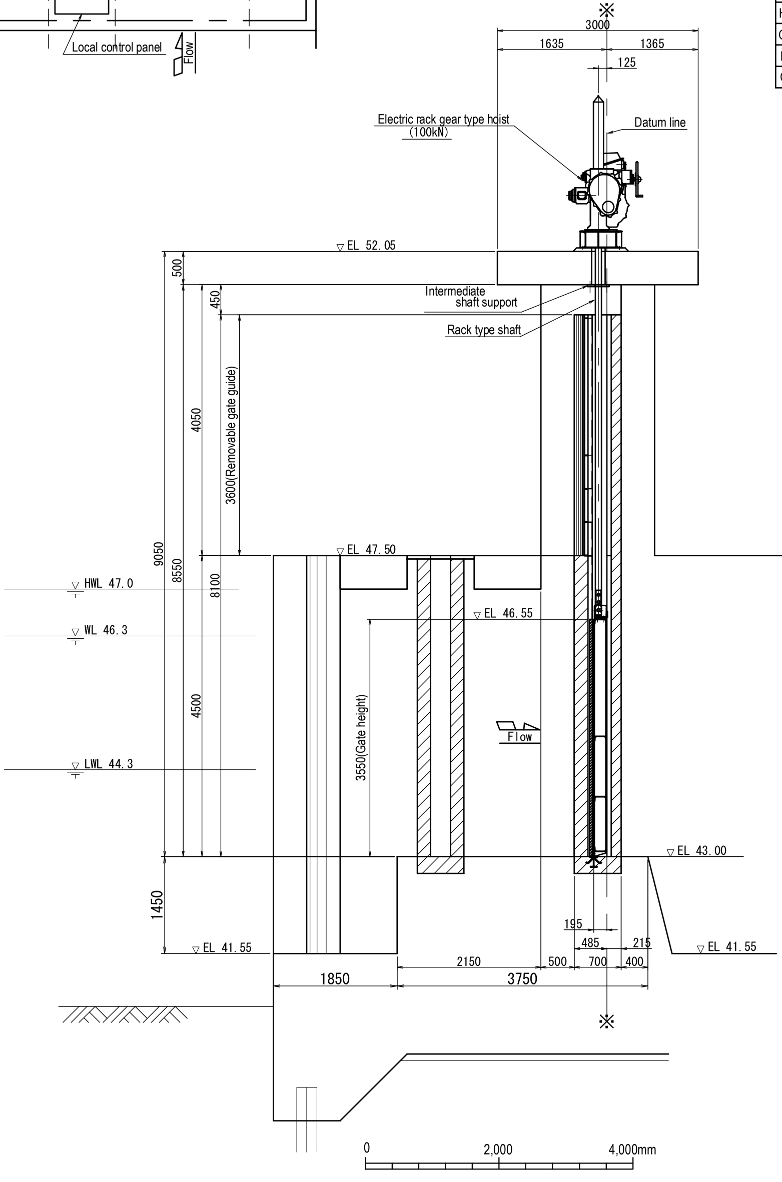
Front view



Plan



Side view



Design Condition		
Type	Slide gate	
Number of gate	2	
Clear span	2.000 m	
Gate height	3.550 m	
Design water depth	3.550 m	
Operation depth	Open	3.550 m
	Close	3.550 m
Sediment height	0.300 m	
Seal type	Upstream 3-side sealing	
Hoist type	Electric rack gear type	
Operating speed	0.3 m/min	
Lifting height	4.500 m	
Operation type	Local and remote control	

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Sahelyia Regulator
General drawing

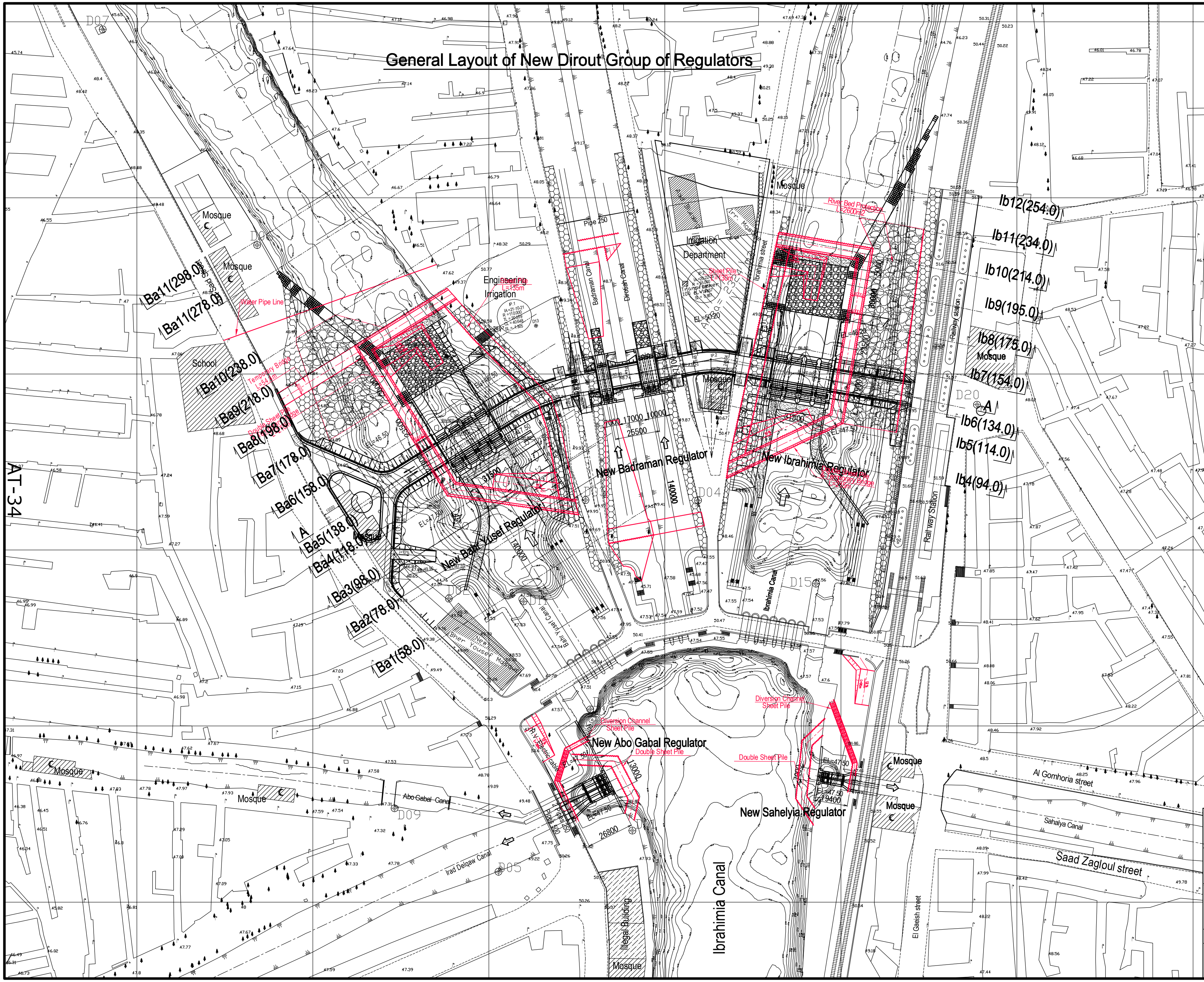
DRW. NO
MS-1

SANYU CONSULTANTS INC.

DATE :	PREPARED BY :	CHECKED BY :	APPROVED BY :
	DATE :	DATE :	DATE :

AT-4. Temporary Works

General Layout of New Dirout Group of Regulators



PROJECT :
Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

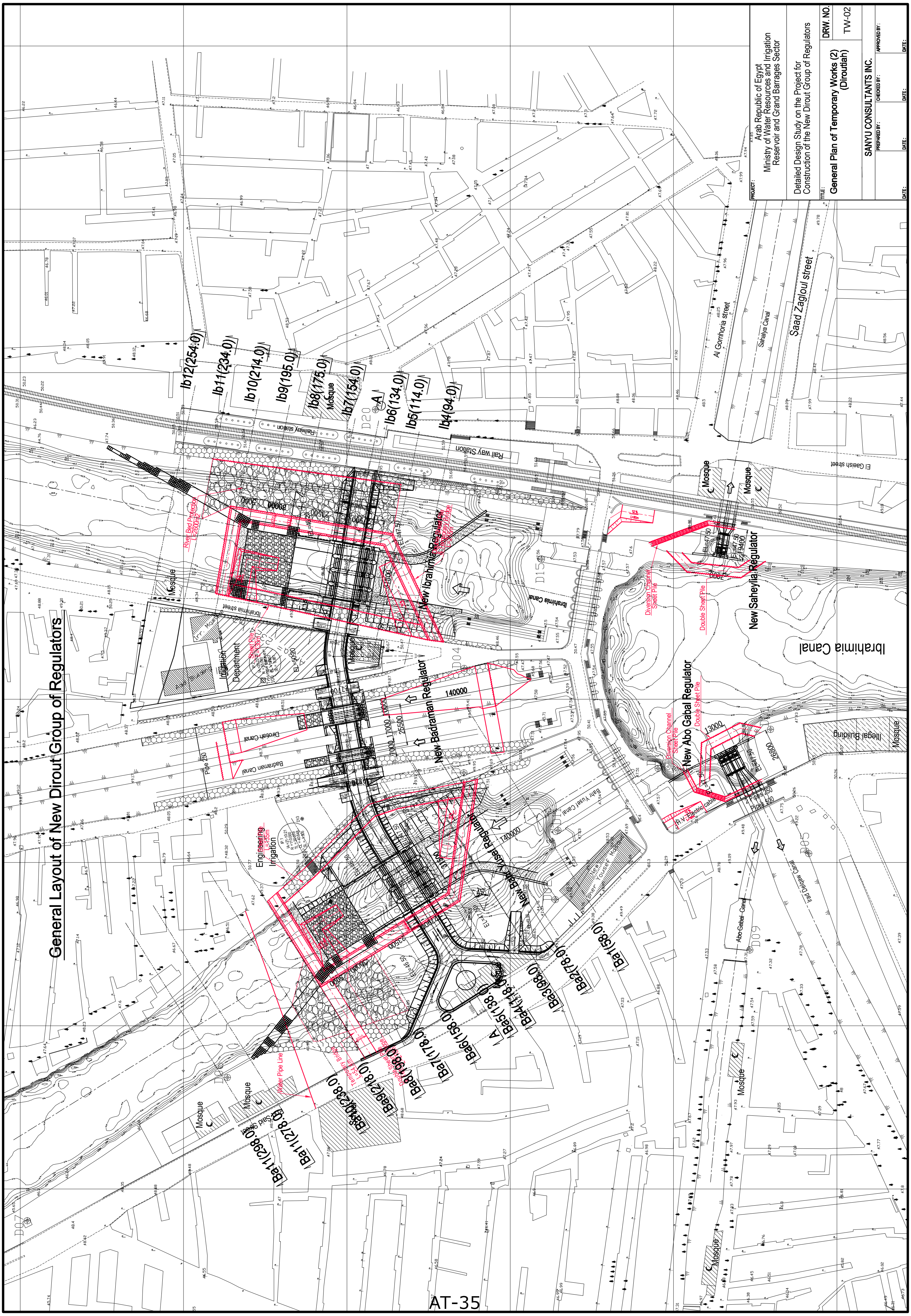
TITLE :
General Plan of Temporary works (1)
(Badraman)

DRW. NO.
TW-01

SANYU CONSULTANTS INC.

DATE :	PREPARED BY : DATE :	CHECKED BY : DATE :	APPROVED BY : DATE :

General Layout of New Dirout Group of Regulators



PROJECT :
Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

TITLE :
General Plan of Temporary Works (2)
(Diroutiah)

DRW. NO.
TW-02

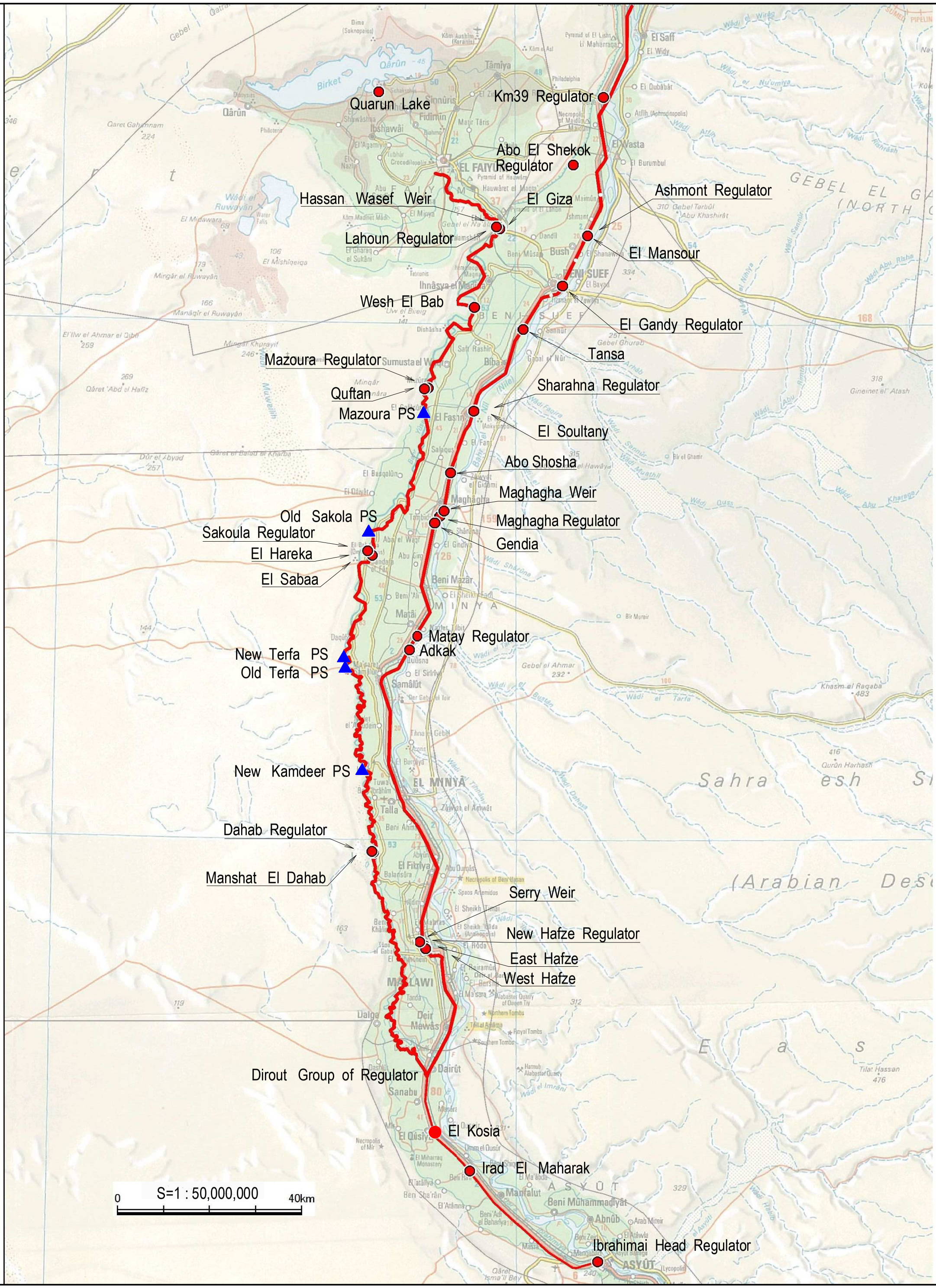
SANYU CONSULTANTS INC.

PREPARED BY : DATE :
CHECKED BY : DATE :
APPROVED BY : DATE :
DATE :

AT-5. Water Management System

Project Location Map

S=1 : 50,000,000



LEGEND

🟥	: MAIN CANAL
●	: REGULATOR, INTAKE, WEIR, LAKE
▲	: PUMP STATION

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

Project Location Map	DRW. NO. WM-1

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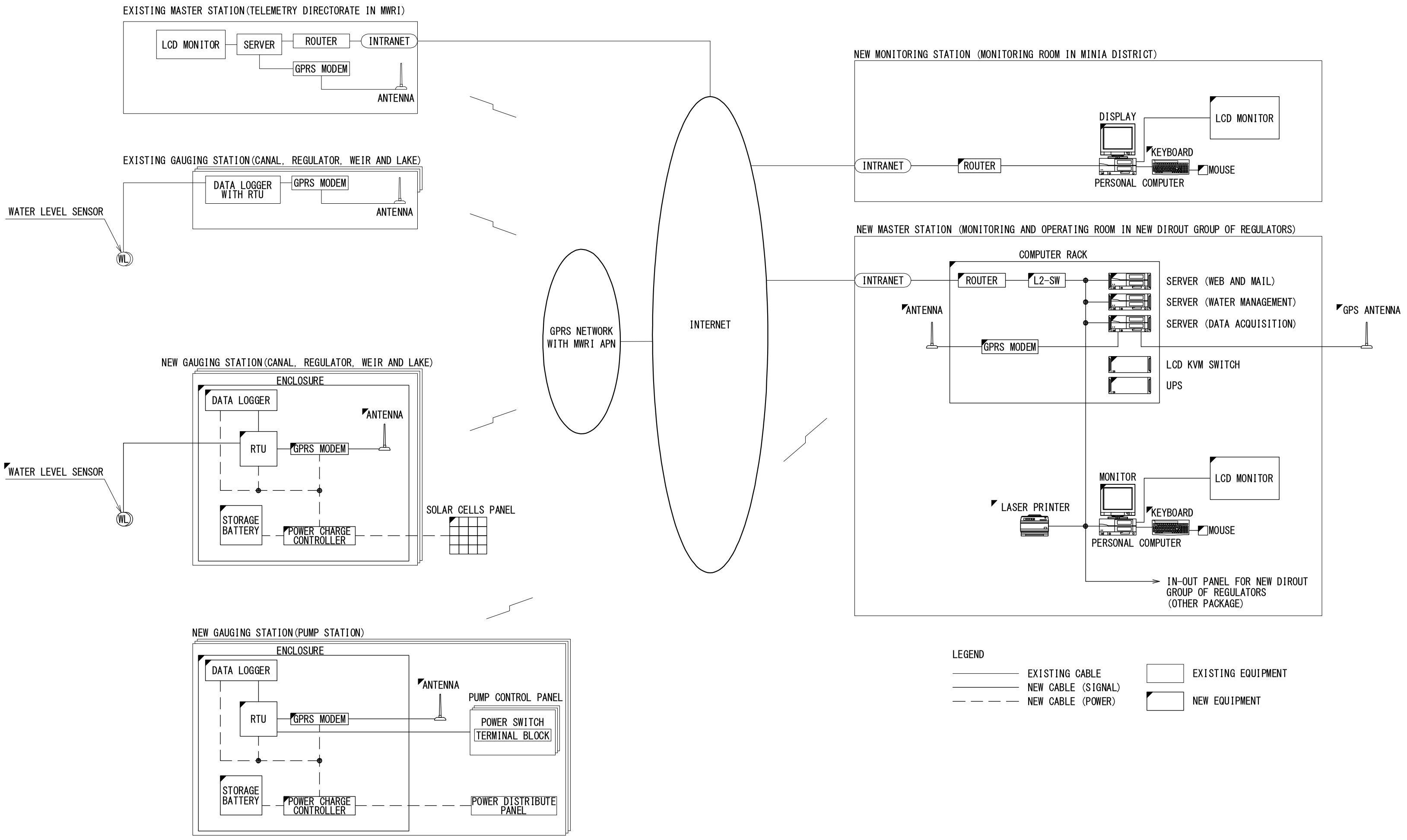
	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

PLATE NO. : 2

SYSTEM DIAGRAM



QUANTITY OF GAUGING STATION

TYPE-A (ONE WATER LEVEL SENSOR)

	IBRAHIMIA	BAHR YUSEF
ASSIUT	0	0
WEST MINIA	1	0
EAST MINIA	1	0
BENI SUEF	0	1
FAYOUM	0	1

TYPE-B (TWO WATER LEVEL SENSORS)

	IBRAHIMIA	BAHR YUSEF
ASSIUT	3	0
WEST MINIA	0	5
EAST MINIA	7	0
BENI SUEF	7	7
FAYOUM	0	0

TYPE-PUMP

	BAHR YUSEF
ASSIUT	0
WEST MINIA	3
EAST MINIA	0
BENI SUEF	2
FAYOUM	0

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

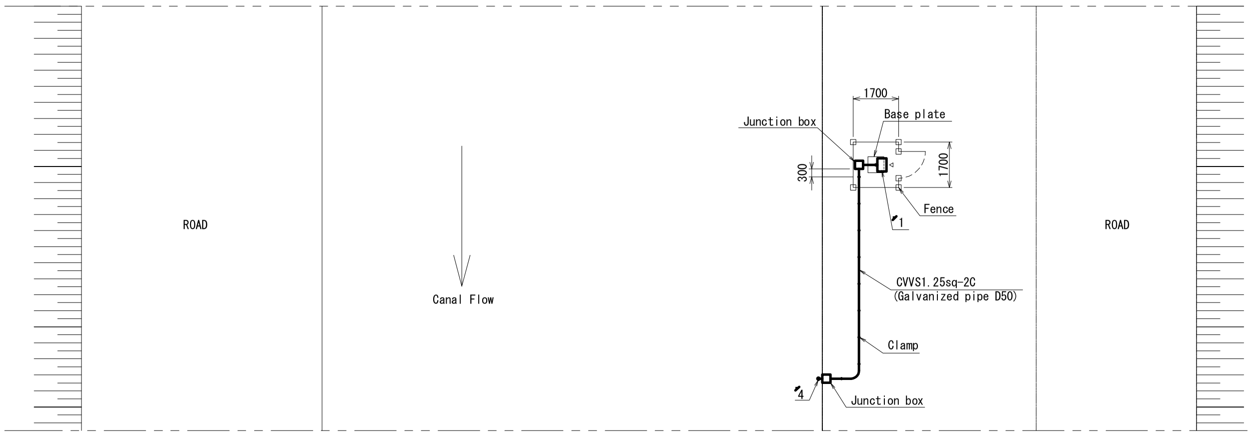
SYSTEM DIAGRAM

DRW. NO.
WM-2

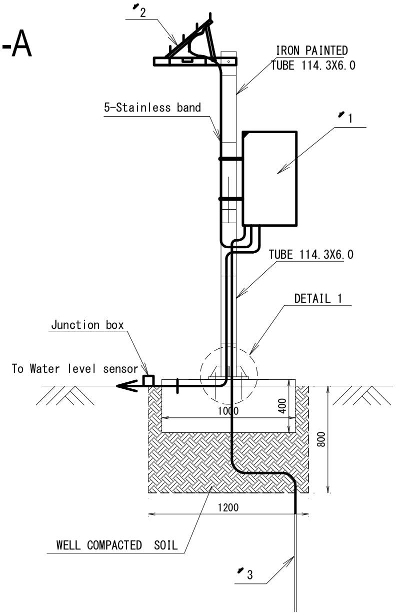
SANYU CONSULTANTS INC.

PREPARED BY : CHECKED BY : APPROVED BY :
DATE : DATE : DATE : DATE :

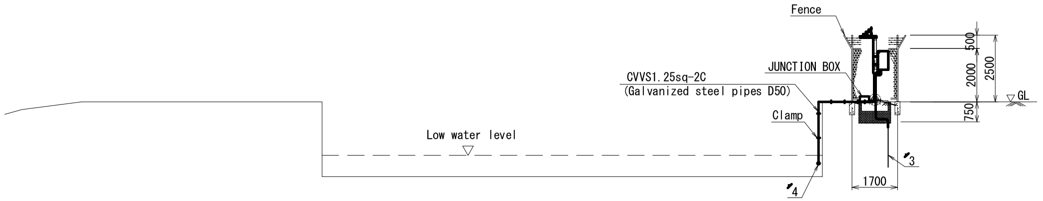
TYPICAL FACILITY LAYOUT PLAN FOR GAUGING STATION TYPE-A



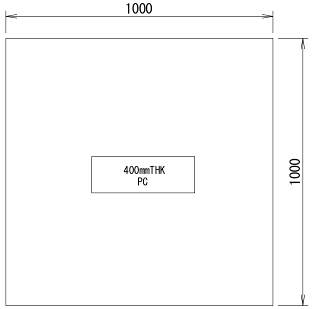
TYPICAL LOCATION
(1:100)



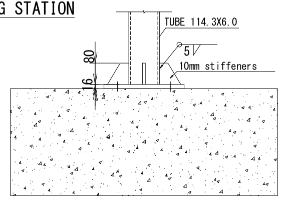
ELEVATION OF GAUGING STATION
(1:20)



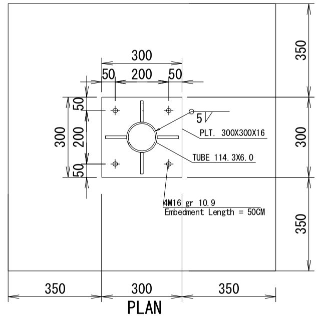
CROSS SECTION
(1:100)



PLAIN CONCRETE DIMENSIONS
(1:10)



ELEVATION
(1:10)



PLAN
(1:10)

NOTE :
a) Fence must be set around the gauging station
b) When the facility installed can be identified from outside, special precautionary measures from theft should accompany itself
c) Especially, the measurement device installed on the outside must set up where it is not stolen easily
d) Outdoor wiring of cable must use the pipe or the cable trough
e) Indoor wiring of cable must use the cable duct or pipe
f) JUNCTION BOX must be set up when there is bending of the cable three times
g) Pipe must be the stainless steel or the galvanizing steel
h) The total amount of the sectional area of the cable must be adjusted to 30[%] or less of the sectional area in pipe, duct and trough
i) Pipe must be clasped by holdfast. And, holdfast should be clamped with the anchor bolt.
j) Clamping pipe by the holdfast from JUNCTION BOX within 500[mm]
k) The holdfast is clasped by intervals within 1500[mm]
l) Length of cable must be less than 100[m]
m) Copper plate for the grounding should be installed near the station, and laid on underground 700 mm or more
n) Resistance of copper plate should be less than 100 [ohm]
o) Solar panel should be set up in the direction where the cell side is facing to the sun
p) Irradiating sunlight onto cell side of solar panels should not be obstructed
q) The inclination angle of solar panel must be adjusted after installed
r) Equipments must protect from the induced lightning

LIST OF EQUIPMENT

No	ITEM	REMARK
1	ENCLOSURE	
2	SOLAR PANEL	
3	GROUNDING ROD	
4	WATER LEVEL SENSOR	

LEGEND :

— NEW CABLE

▭ NEW EQUIPMENT

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

TYPICAL FACILITY LAYOUT PLAN FOR
GAUGING STATION TYPE-A

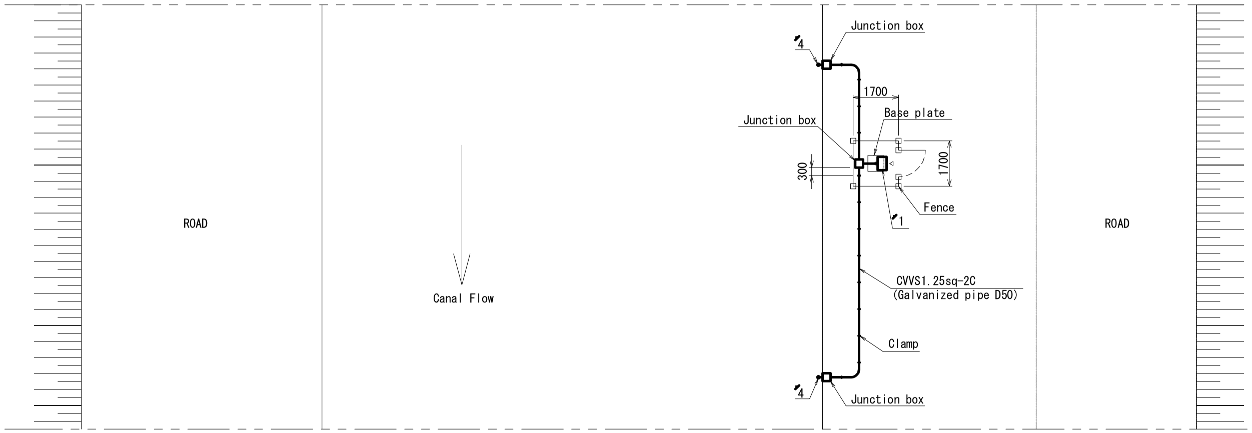
DRW. NO.
WM-3

SANYU CONSULTANTS INC.

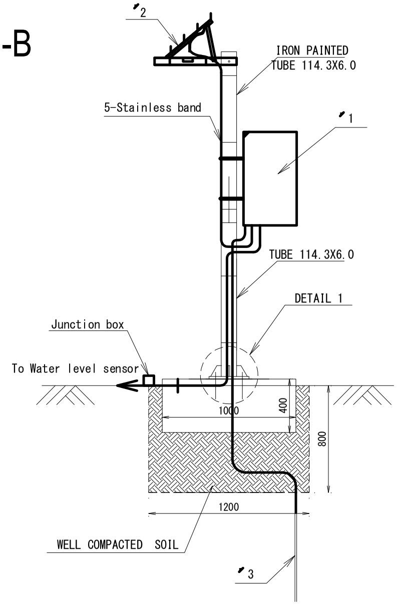
	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

PLATE NO.: 4

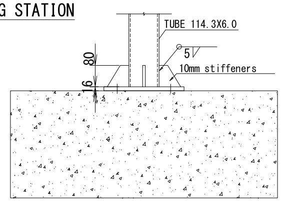
TYPICAL FACILITY LAYOUT PLAN FOR GAUGING STATION TYPE-B



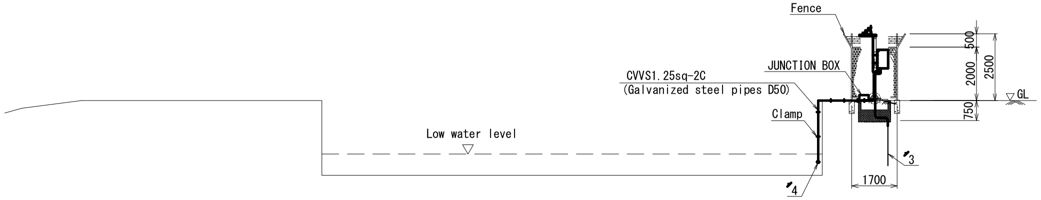
TYPICAL LOCATION
(1:100)



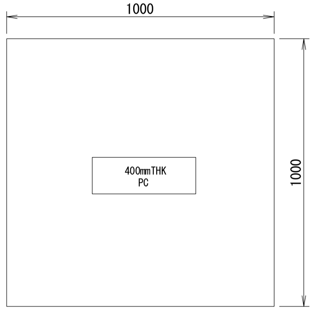
ELEVATION OF GAUGING STATION
(1:20)



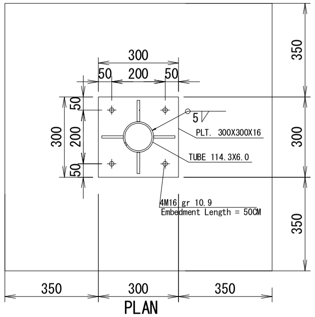
ELEVATION
(1:10)



CROSS SECTION
(1:100)



PLAIN CONCRETE DIMENSIONS
(1:10)



PLAN
(1:10)

NOTE :
a) Fence must be set around the gauging station
b) When the facility installed can be identified from outside, special precautionary measures from theft should accompany itself
c) Especially, the measurement device installed on the outside must set up where it is not stolen easily
d) Outdoor wiring of cable must use the pipe or the cable trough
e) Indoor wiring of cable must use the cable duct or pipe
f) JUNCTION BOX must be set up when there is bending of the cable three times
g) Pipe must be the stainless steel or the galvanizing steel
h) The total amount of the sectional area of the cable must be adjusted to 30[%] or less of the sectional area in pipe, duct and trough
i) Pipe must be clasped by holdfast. And, holdfast should be clamped with the anchor bolt.
j) Clamping pipe by the holdfast from JUNCTION BOX within 500[mm]
k) The holdfast is clasped by intervals within 1500[mm]
l) Length of cable must be less than 100[m]
m) Copper plate for the grounding should be installed near the station, and laid on underground 700 mm or more
n) Resistance of copper plate should be less than 100 [ohm]
o) Solar panel should be set up in the direction where the cell side is facing to the sun
p) Irradiating sunlight onto cell side of solar panels should not be obstructed
q) The inclination angle of solar panel must be adjusted after installed
r) Equipments must protect from the induced lightning

LIST OF EQUIPMENT

No	ITEM	REMARK
1	ENCLOSURE	
2	SOLAR PANEL	
3	GROUNDING ROD	
4	WATER LEVEL SENSOR	

LEGEND :

—	NEW CABLE
▭	NEW EQUIPMENT

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

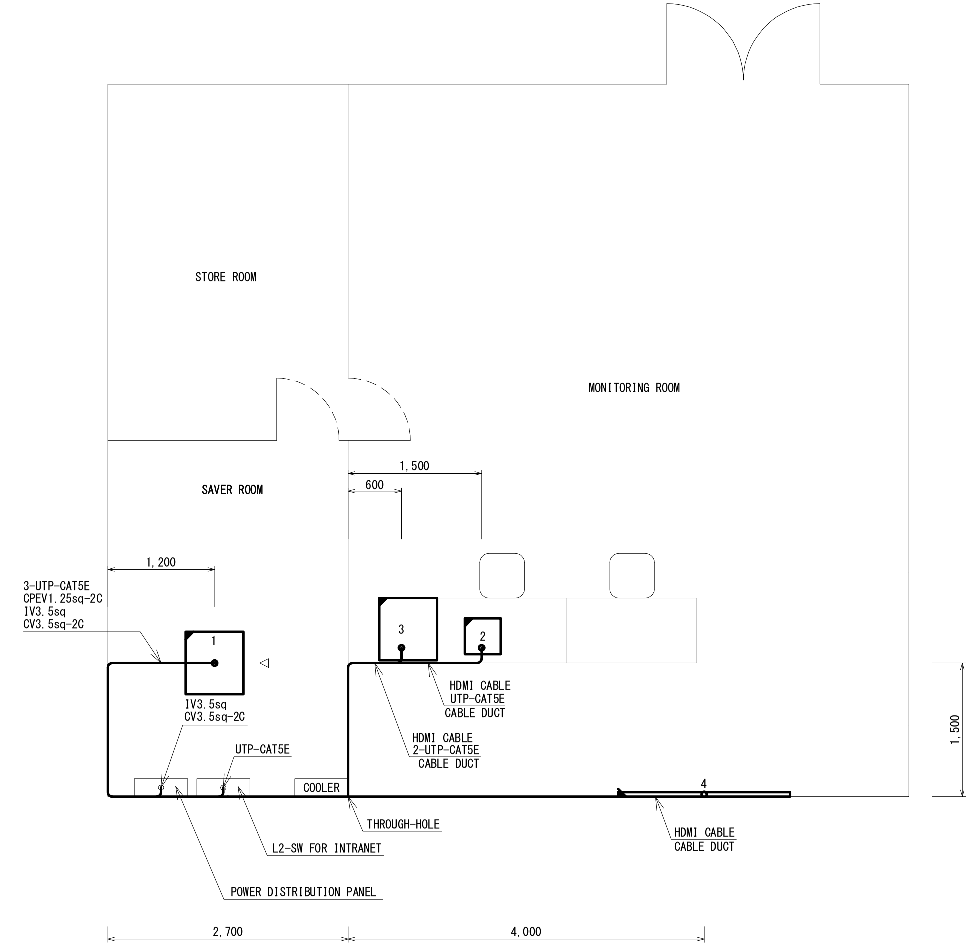
TYPICAL FACILITY LAYOUT PLAN FOR
GAUGING STATION TYPE-B

DRW. NO.
WM-4

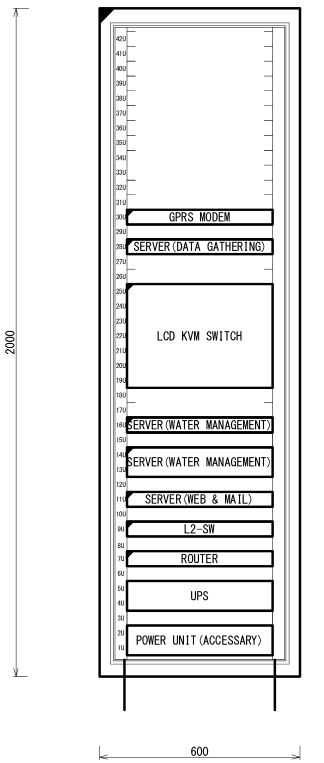
SANYU CONSULTANTS INC.

	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

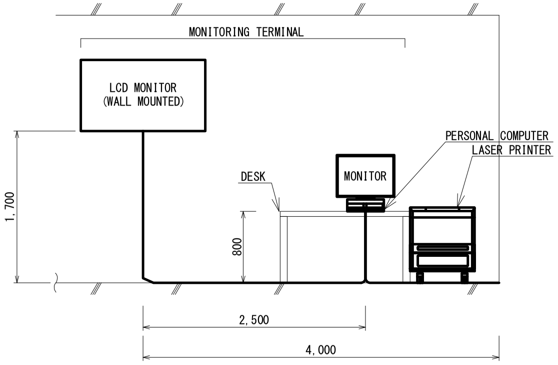
FLOOR PLAN FOR MONITORING AND OPERATING ROOM



Floor Plan
(S=1/30)



Front Elevation of COMPUTER RACK
(S=1/8)



Front Elevation of MONITORING TERMINAL
(S=1/30)

NOTE :
a) Outdoor wiring of cable must use the pipe or the cable trough
b) Indoor wiring of cable must use the cable duct or pipe
c) JUNCTION BOX must be set up when there is bending of the cable three times
d) Pipe must be the stainless steel or the galvanizing steel
e) The total amount of the sectional area of the cable must be adjusted to 30[%] or less of the sectional area in pipe, duct and trough
f) Pipe must be clasped by holdfast. And, holdfast should be clamped with the anchor bolt.
g) Clamping pipe by the holdfast from JUNCTION BOX within 500[mm]
h) The holdfast is clasped by intervals within 1500[mm]
i) Length of Metallic LAN Cable Length must be less than 100[m]
j) Equipments must protect from the induced lightning
k) Put neither wiring cable for the signal nor the wiring cable for the electric power in the same pipe
l) The facility set up must adopt the requirement which means earthquake-proof, shockproof, water-proof and any proof the government required.
m) The facility must be painted from surroundings of the site in an unremarkable color.

LIST OF EQUIPMENT

No.	NAME OF EQUIPMENT	REMARKS
1	COMPUTER RACK	
2	PERSONAL COMPUTER (MONITORING TERMINAL)	
3	LASER PRINTER	
4	LCD MONITOR (60 INCH)	WALL MOUNTED

LEGEND
▭ : NEW EQUIPMENT
— : NEW CABLE
▭ : EXISTING EQUIPMENT

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

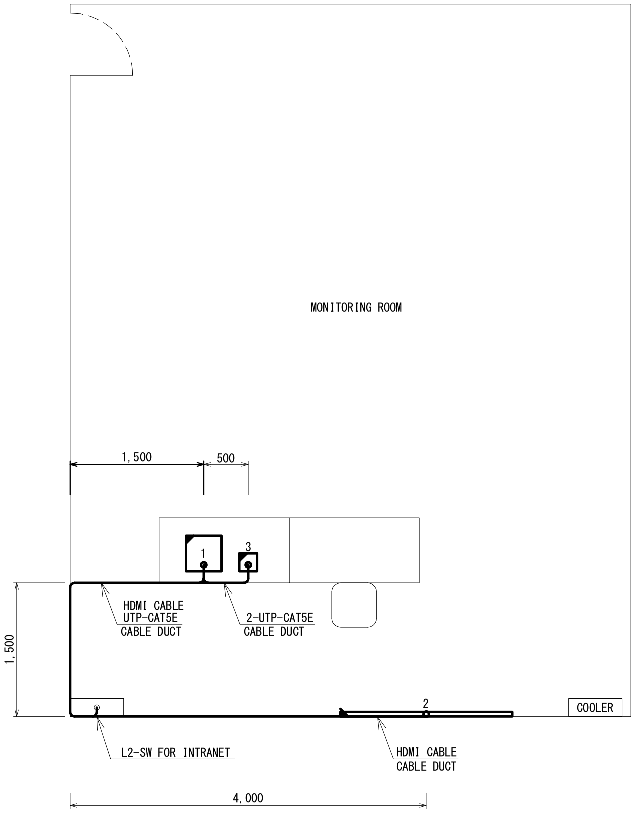
Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

FLOOR PLAN FOR MONITORING AND OPERATING ROOM	DRW. NO. WM-5

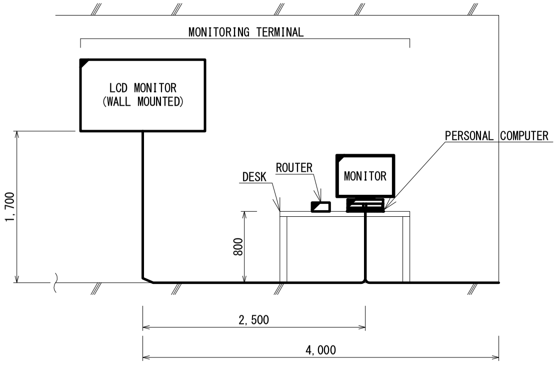
SANYU CONSULTANTS INC.

	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :

FLOOR PLAN FOR MONITORING ROOM IN MINIA



Floor Plan
(S=1/30)



Front Elevation of MONITORING TERMINAL
(S=1/30)

LIST OF EQUIPMENT

No.	NAME OF EQUIPMENT	REMARKS
1	MONITORING TERMINAL	
2	LCD MONITOR	
3	ROUTER	

LEGEND

◩ : NEW EQUIPMENT
— : NEW CABLE
▭ : EXISTING EQUIPMENT

NOTE :
a) Outdoor wiring of cable must use the pipe or the cable trough
b) Indoor wiring of cable must use the cable duct or pipe
c) JUNCTION BOX must be set up when there is bending of the cable three times
d) Pipe must be the stainless steel or the galvanizing steel
e) The total amount of the sectional area of the cable must be adjusted to 30[%]
or less of the sectional area in pipe, duct and trough
f) Pipe must be clasped by holdfast. And, holdfast should be clamped with the anchor bolt.
g) Clamping pipe by the holdfast from JUNCTION BOX within 500[mm]
h) The holdfast is clasped by intervals within 1500[mm]
i) Length of Metallic LAN Cable Length must be less than 100[m]
j) Equipments must protect from the induced lightning
k) Put neither wiring cable for the signal nor the wiring cable for the electric power in the same pipe
l) The facility set up must adopt the requirement which means earthquake-proof, shockproof, water-proof
and any proof the government required.
m) The facility must be painted from surroundings of the site in an unremarkable color.

Arab Republic of Egypt
Ministry of Water Resources and Irrigation
Reservoir and Grand Barrages Sector

Detailed Design Study on the Project for
Construction of the New Dirout Group of Regulators

FLOOR PLAN FOR MONITORING
ROOM IN MINIA

DRW. NO.
WM-6

SANYU CONSULTANTS INC.

	PREPARED BY :	CHECKED BY :	APPROVED BY :
DATE :	DATE :	DATE :	DATE :